Chlamydia trachomatis in Tasmania: improving public health surveillance methods to reduce the burden of disease

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Abstract

Background: Genital *Chlamydia trachomatis* (chlamydia) is Australia's most frequently notified communicable disease. Associated costs have been estimated at between AUD$90-$160 million per year. Chlamydia infection can lead to significant health complications including infertility in both sexes. Public health surveillance data based on statutory notifications of cases provides epidemiological information useful in focussing chlamydia control efforts, however the data is limited without knowledge of testing patterns. Clinical guidelines recommend annual tests for all sexually active people aged <30 years, and mathematical modelling demonstrates that large reductions in chlamydia prevalence are possible, provided there is adequate testing coverage.

Aims: To investigate, in Tasmania: i) increasing rates of chlamydia notifications by demographic and risk profiles and behavioural characteristics; ii) rates of testing, retesting and test positivity; iii) the feasibility and usefulness of collecting population-level testing data; iv) potential clinical and behavioural influences on test positivity trends; v) whether testing effort is reaching strategic and clinical guidelines; vi) the role and type of healthcare provider in chlamydia testing.

Methods: Four Tasmanian datasets were analysed i) statutory data on all chlamydia cases notified from 2001-2010; ii) additional surveillance data collected on all notified cases of chlamydia from 2001-2010; iii) de-identified laboratory testing data collected from 2001-2010; and iv) linked laboratory testing data collected in 2012 and 2013. Data were analysed by sex, geographic

location, indigenous status, sexual exposure, reason for testing and healthcare provider. Testing patterns and positivity levels were examined and compared with data collected on notified cases. Population rates of testing and retesting, and test positivity were measured by sex, healthcare provider, geographic location and socioeconomic indicators.

Results: Females were more likely to have been tested as a result of screening, males as a result of presenting with symptoms or from contact tracing. General practitioners identify the majority of cases. Testing and retesting rates are lower than recommended levels. Testing and test positivity increased from 2001 to 2010, most significantly in males and females aged 15-24 years; testing coverage was higher in females (21%) than males (6%) and test positivity was higher in males (16%) than females (10%). In 2012 and 2013, less testing and higher test positivity was found in areas of most disadvantage; retest rates at 3 months were low in males (10%) and females (14%), and retest positivity high in males (35%) and females (23%).

Conclusions:

Chlamydia infection is a significant public health issue. After allowing for testing effort, an increase in notifications in young people was found in Tasmania. Testing levels are below those required to decrease chlamydia prevalence. Analysis of chlamydia testing, retesting and positivity trends can inform the development, monitoring and evaluation of prevention and control activities and improves the interpretation of notification data.

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Statement of authorship

This thesis includes chapters for which the author (NS) is not the sole author. NS took the lead in this research in that she designed the research, undertook all the data analysis and wrote the manuscripts however she was assisted by co-authors. The contributions of each author are acknowledged below.

Chapter 2

Stephens N, O'Sullivan M, Coleman D, Shaw K. *Chlamydia trachomatis* in Tasmania 2001-2007: rising notification trends. *Aust NZ J Public Health* 2010; 34: 120-125.

The contribution of each author: NS conceptualised the study and the manuscript, undertook all the data analyses, led the interpretation of the data, drafted the manuscript and incorporated critical revisions of the manuscript; MO was involved in the conceptualisation of the manuscript, acquisition of the data, contributed to the interpretation of the data and revision of the manuscript; DC was involved in the conceptualisation of the manuscript, acquisition of the data, contributed to the interpretation of the data and revision of the manuscript; KS was involved in the conceptualisation of the manuscript, acquisition of the data, contributed to the interpretation of the data and revision of the manuscript.

Chapter 3

Stephens N, Coleman D, Shaw K, O'Sullivan M, Venn A. Improving public health surveillance of chlamydia: analysis of population-level positivity trends. *Sexual Health* 2015; 12(4): 369-371.

The contribution of each author: NS was involved in the acquisition of the data, the conceptualisation of the study, conceptualised the manuscript, undertook all the data analyses, led the interpretation of the data, drafted the manuscript and incorporated critical revisions of the manuscript; DC was involved in the conceptualisation of the study, acquisition of the data, contributed to the interpretation of the data and revision of the manuscript; KS was involved in the conceptualisation of the study, contributed to the interpretation of the data and revision of the manuscript; MO was involved in the conceptualisation of the study, contributed to the interpretation of the data and revision of the manuscript; AV was involved in the conceptualisation of the study, contributed to the interpretation of the data and revision of the manuscript.

Chapter 4

Stephens N, Coleman D, Shaw K, O'Sullivan M, Vally H, Venn A. Exploration of testing practices and population characteristics support an increase in chlamydia positivity in Tasmania between 2001 and 2010. *Aust NZ J Public Health* 2015; doi: 10.1111/1753-6405. 12502 [Epub ahead of print].

The contribution of each author: NS conceptualised the study, was involved in the acquisition of the data, conceptualised the manuscript, undertook all the data analyses, led the interpretation of the data, drafted the manuscript and incorporated critical revisions of the manuscript; DC was involved in the acquisition of the data, conceptualisation of the study, contributed to the interpretation of the data and revision of the manuscript; KS was involved in the acquisition of the data, conceptualisation of the study, contributed to the

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Chapter 5

Stephens N, Coleman D, Shaw K, O'Sullivan M, Cooley L, McGregor A, Vally H, Venn A. Testing for chlamydial infection: are we meeting clinical guidelines? Evidence from a state-level data linkage analysis for 15-29 year-olds. Currently under review with the *Medical Journal of Australia*.

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was involved in the acquisition of the data, conceptualisation of the study, contributed to the interpretation of the data and revision of the manuscript.

Chapter 6

Stephens N, Coleman D, Shaw K, Venn A. Geographical differences in *Chlamydia trachomatis* testing in 15-29 year-olds in Tasmania: findings from a statewide laboratory data linkage study. Accepted for publication in the *Australian Journal of Rural Health* and currently awaiting allocation to an issue.

The contribution of each author: NS conceptualised the study, was involved in the acquisition of the data, conceptualised the manuscript, undertook all the data analyses, led the interpretation of the data, drafted the manuscript and incorporated critical revisions of the manuscript; DC was involved in the acquisition of the data, conceptualisation of the study, contributed to the interpretation of the data and revision of the manuscript; KS was involved in the conceptualisation of the study, contributed to the interpretation of the data and revision of the manuscript; AV was involved in the acquisition of the data, conceptualisation of the study, contributed to the interpretation of the data and revision of the manuscript.

Chapter 7

Stephens N, Coleman D, Shaw K, O'Sullivan M, Cooley L, McGregor A, Venn A. Chlamydia retesting and retest positivity rates: results from a statewide laboratory data linkage study in Tasmania, 2012-2013.

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Signed by primary supervisor, Professor Alison Venn

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Publications

Publications directly arising from the research described in this thesis

Chapter 2

Stephens N, O'Sullivan M, Coleman D, Shaw K. *Chlamydia trachomatis* in Tasmania 2001-2007: rising notification trends. *Aust NZ J Public Health* 2010; 34: 120-125.

Chapter 3

Stephens N, Coleman D, Shaw K, O'Sullivan M, Venn A. Improving public health surveillance of chlamydia: analysis of population-level positivity trends. *Sexual Health* 2015; 12(4): 369-371.

Chapter 4

Stephens N, Coleman D, Shaw K, O'Sullivan M, Vally H, Venn A. Exploration of testing practices and population characteristics support an increase in chlamydia positivity in Tasmania between 2001 and 2010. *Aust NZ J Public Health* 2015; doi: 10.1111/1753-6405. 12502 [Epub ahead of print].

Chapter 5

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Chapter 7

Stephens N, Coleman D, Shaw K, O'Sullivan M, McGregor A, Cooley L, Venn A. Chlamydia retest and retest positivity rates: results from a state-wide laboratory data linkage study in Tasmania, 2012-2013. Currently under review with *Sexual Health*.

Appendix A

Shaw K, **Stephens N**, Coleman D, O'Sullivan M. Role of the general practitioner in testing for genital *Chlamydia trachomatis* infection: an analysis of enhanced surveillance data. *Sexual Health* 2009; 6; 208-212.

Chapter 1

Introduction

Chapter 1 — Introduction

1.1 Definition of chlamydia

Chlamydiae are obligate intracellular bacteria with three species that most commonly cause human disease: *Chlamydia psittaci, Chlamydia trachomatis,* and *Chlamydia pneumonia. Chlamydia trachomatis* serovars B and D through K are responsible for sexually acquired infections and perinatally transmitted infections of the neonate and infant (1). Genital infection with *C. trachomatis* is the focus of this dissertation and will be referred to as "chlamydia".

1.2 Epidemiology of chlamydia

1.2.1 Prevalence of chlamydia

Estimates reported by the World Health Organisation, based on data for 2005 to 2012, show the pooled global prevalence of chlamydia to be 4.2% (95% UI: 3.7-4.7%) in women and 2.7% (95% UI: 2.0-3.6%) in men (2). Over 120 million new infections are estimated to occur globally each year (3), with the annual cost of treating acute infections and the complications they cause estimated to be US$10 billion (4, 5). Australian healthcare costs associated with chlamydial infection are estimated at between AUD$90-$160 million a year (6).

In Australia, chlamydia prevalence estimates have been based on sub-populations and therefore may not represent the true population prevalence (7). Reported prevalence varies across populations, with age the strongest predictor of risk (8). Vajdic et al's (2005) systematic review of the prevalence of genital chlamydial infection in Australia between 1977 and 2004 included 40 studies of

50 populations, however only one of the included studies was population-based (based on a complete population), with the majority based on selected groups within populations. They found prevalence to be higher in sexual health and related clinics than community-based estimates and a mean overall prevalence of 4.6%, but noted the over-sampling of high-risk groups (9). Lewis et al (2012) more recently conducted a systematic review and meta-analysis of chlamydia prevalence in Australia from 1997-2011. Seventy-six studies were included in their review but they reported limitations by heterogeneity within surveyed populations, and variations in sampling methodologies and data reporting. Their analysis of five studies conducted post-2005 found a prevalence of 5.0% in women aged less than 25 years, and for men aged less than 30 years over the entire review period, a prevalence of 3.9%. Prevalence was higher for those attending sexual health, family planning or youth clinics, in Indigenous males and females aged less than 25 years, and for rectal infection in men who have sex with men (10).

1.2.2 Incidence of chlamydia

Very few studies have examined the incidence rate of new infections due to the large population cohorts that would need to be tested at regular intervals (11). Walker et al's (2012) study of 1,116 women aged 16 to 25 years attending general practice, family planning and sexual health clinics in three Australian jurisdictions (Australian Capital Territory, New South Wales and Victoria) found an incidence rate of 4.4 per 100 person years (95% CI: 3.3-5.9), consistent across type of healthcare provider (12). In order to provide an estimate at a population level, Ali et al (2015) developed a Bayesian statistical approach to calibrate the

parameters of a decision-pathway tree against national data on notifications and tests conducted between 2001 and 2013. They utilised a probabilistic tree to represent branches along which people could end each calendar year as either acquiring or not acquiring chlamydia infection, developing symptoms, being tested and treated and being notified as a case. Each individual in the population was assigned probability of each step along the branch over the course of each year. They based some probabilities on estimates in the literature, and others by fitting the model to data on the numbers of people tested and numbers diagnosed. They used a stepwise Gaussian process model to allow annual infection and asymptomatic screening probabilities to vary yearly by age group and sex, with all other parameters fixed in time. Their model suggested that the total number of people who acquired chlamydia in Australia over the 12 years increased by approximately 120%; the annual incidence estimate of 1.54% in 2013 was a 90% increase over that in 2001 (0.8%); and that 356,000 people acquired chlamydia in 2013, which is 4.3 times the number of reported diagnoses (13).

1.3 Public health significance

Chlamydia is of public health significance because of the short and long-term sequelae associated with untreated infection, including urethritis, acute epididymitis and infertility in males, and cervicitis, urethritis, pelvic inflammatory disease, infertility, chronic pelvic pain and tubal pregnancy in females, and the association between chlamydial infection and increased transmission of other sexually transmissible infections. A large proportion of infections are asymptomatic and as a result go undiagnosed, increasing the

likelihood of associated sequelae (3) (Table 1.1). The costs of treating subfertility due to chlamydia are high as tubal surgery and in vitro fertilization are expensive; and the cost of treating the complications of undiagnosed infection, including pelvic inflammatory disease and tubal infertility, are high both in psychosocial and financial terms (8).

Table 1.1: Chlamydial infection - symptoms, sequelae and other factors

Clinical manifestations (3, 8)	**Other** (3)
• **Males**: urethral discharge (urethritis), epididymitis, orchitis, infertility. • **Females**: cervicitis (infection of the neck of the womb), endometritis, salpingitis (fallopian tube inflammation), pelvic inflammatory disease, infertility, preterm rupture of membranes during pregnancy ('waters breaking' too soon), perihepatitis (inflammation of the liver coating); urethritis, chronic pelvic pain, tubal pregnancy. • **Both sexes**: proctitis (inflammation of the rectum), pharyngitis (inflammation of the throat),	• It is estimated that up to 85% of women and over 50% of men are asymptomatic when infected with chlamydia (3, 14, 15). • The risk of infection from an infected male to his female partner is estimated to be 40% and from an infected female to male 30% (3). • If untreated, chlamydial infection may persist for years (3). Chlamydia is an important cause of both PID and tubal factor infertility (TFI). Every 1000 chlamydia infections in women aged 16 to 44 years gives rise to approximately 171 episodes of PID; and 29% of

Reiter's syndrome (reactive arthritis.	TFI is attributable to chlamydia (16). • Chlamydia infection facilitates the transmission of HIV infection in both males and females (17).

1.4 Treatment of chlamydia

Inexpensive and effective treatment is available for chlamydial infection (8), with current Australian guidelines recommending azithromycin or doxycycline as principal antibiotic treatment options (18). For uncomplicated urogenital infections, a single 1g dose of azithromycin is recommended; and for anorectal infections, one week of doxycycline (100mg twice daily) (19). Recent data has suggested that azithromycin may not be as effective as expected, with a wide range of treatment failure rates reported (5.8%-22.6%) (20). Other studies, however, have demonstrated the efficacy of azithromycin as 97% (21). Differences between site of infection, immune response, drug pharmacokinetics, organism load, auto-inoculation from rectum to cervix in women and the genital microbiome are suspected to play a role in treatment success (19). Randomised controlled trials are needed to evaluate azithromycin's efficacy and to determine whether extended doses can be successful in the treatment of rectal (22) and pharyngeal (23) infections.

1.5 Public health surveillance

Public health surveillance is the ongoing and systematic collection, analysis, interpretation and dissemination of data (Figure 1.1) (24, 25). Health data is collected to identify trends, provide guidance for policy development and resource allocation, evaluate policy and the impact of disease control programs, provide early alert of disease outbreaks, describe the epidemiology of diseases and meet international and local reporting requirements (26). Often, surveillance data represents only a proportion (the 'notified fraction') of the total incidence of disease (Figure 1.2) and the notified fraction can vary over time (26).

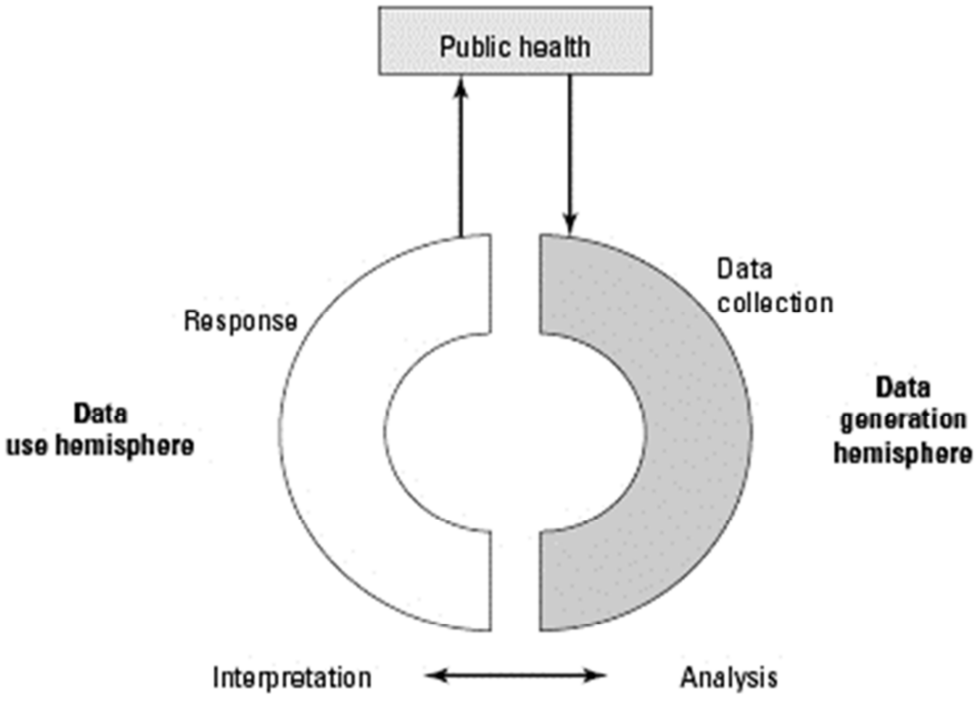

Figure 1.1: Surveillance and response conceptual framework[1]

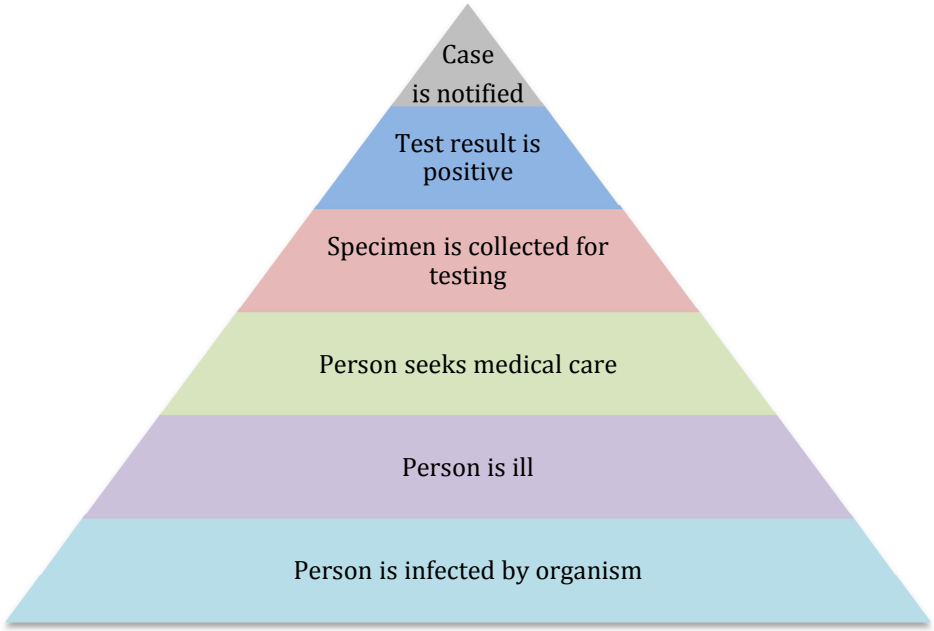

Figure 1.2: Notified fraction

1.6 Chlamydia surveillance

National surveillance of chlamydial infections has been in place in Australia since 1994 (27), and is an important component of public health management for chlamydia prevention and control (8). The main form of chlamydia surveillance is passive reporting of cases to health departments in each Australian state and territory, by doctors and laboratories. Along with other notifiable communicable diseases, health departments collect chlamydia notifications under their respective public health legislation and analyse the data for public health purposes ('notification pathway') (Figure 1.3). In addition, the *National Health Security Act 2007* (28) provides a legislative basis for and authorises the

1 Reproduced from Nsubuga P, White ME, Thacker SB, Anderson MA et al. Public Health Surveillance: a tool for targeting and monitoring interventions. In: Jamieson DT, Breman, J.G., Measham, A.R., editor. Disease Control Priorities in Developing Countries, 2nd Edition. Washington, DC: World Bank; 2006.

exchange of health information between jurisdictions and the Australian Government Department of Health to allow for monitoring and reporting at a national level (26). Public health surveillance data are managed based on their classification as sensitive, urgent or routine. Sensitive data include notifications of a condition of particular interest to a jurisdiction at the time of notification (for example, Zika Virus Infection in 2016 due to its rapid spread worldwide and its potential association with microcephaly and neurological disorders (29)). Urgent cases are conditions that require fast public health action to prevent further transmission, such as measles. Routine surveillance cases (such as chlamydia) are those conditions for which public health surveillance is primarily used for monitoring and reporting of trends and to inform and evaluate public health policy and interventions.

Chlamydia surveillance data is used to plan and evaluate policies, prevention activities and management strategies and their effectiveness. The greatest strength of the passive surveillance is its relative ease, being much less resource intensive than active surveillance (such as case follow up). Nationally in Australia, jurisdictions routinely collect the date of specimen collection or diagnosis date, and the person's sex, age and postcode of residence (27, 30) for each diagnosed case of chlamydia. This enables national and local analysis and reporting of notifications by sex, age and geographic location (26, 27, 31). However, as chlamydia surveillance does not routinely collect data on negative tests (people who were tested for chlamydia but received a negative result), the limitations of passive surveillance data include the potential for bias by testing effort, for example the impact of increased or fluctuating patterns of testing over

time (9, 26), and the lack of ability to be able to monitor testing coverage in priority populations (30). In addition, the passive surveillance data is de-identified, that is, names and addresses are removed prior to the doctor or laboratory notifying the result to the local health department, therefore there is no ability to analyse the proportion of reinfections. Further, passive surveillance data does not provide any information on risk factors for acquiring infection, symptom status of notified cases, site of infection, Indigenous status, or behaviour characteristics of notified cases such as reason for testing, choice of healthcare provider or sexual exposure.

Chlamydia notification data are not reliable indicators of population incidence or prevalence (9). Notifications are certain to be underestimates because the majority of tests are performed as a result of the presence of symptoms or through contact tracing partners of diagnosed cases, even though the majority of infections are asymptomatic (14, 15, 32). Chlamydia is equally transmitted in males and females (9), therefore the differences in rates of chlamydia notifications between males and females further highlights the caution required when interpreting the notification data (9).

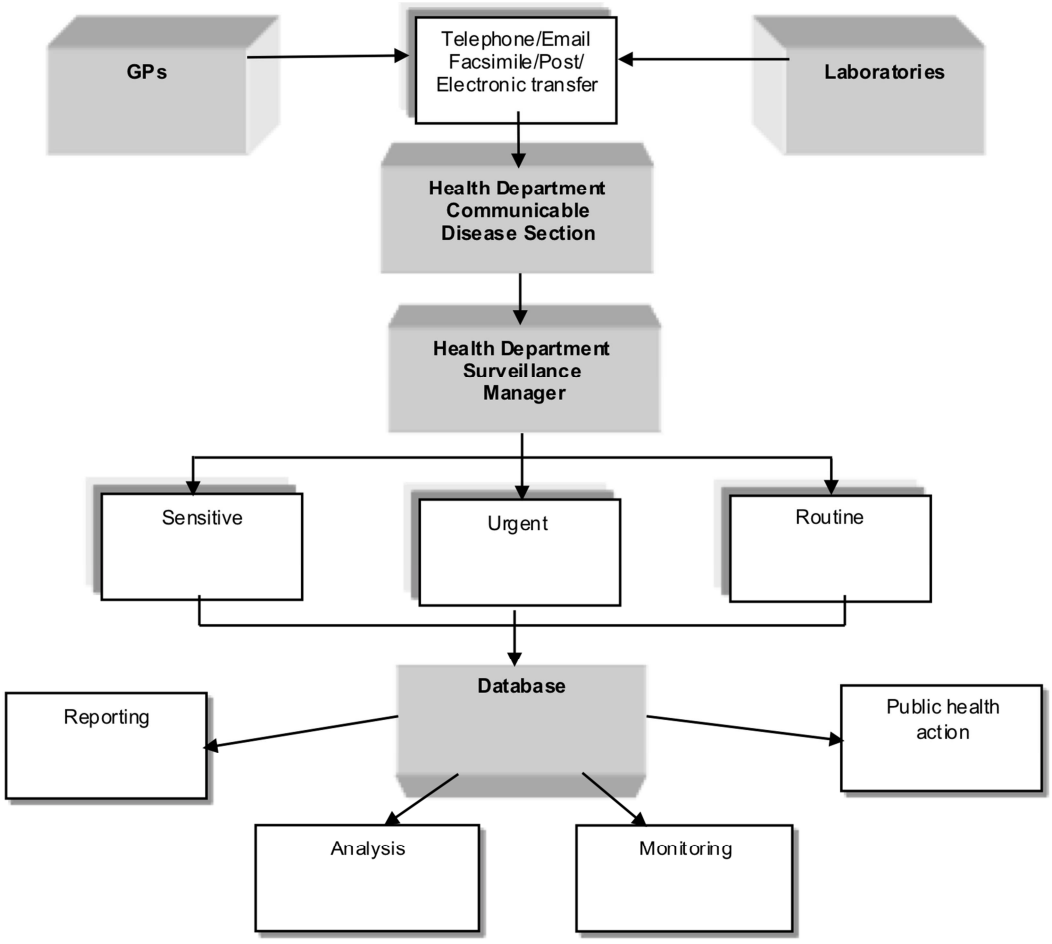

Figure 1.3: Notification pathway

1.7 Notification rates

Chlamydia is the most frequently notified communicable disease in Australia and the number of reports of chlamydia infections have been increasing since the condition first became notifiable in 1994 (33). Between 2007 and 2014, the number of notifications increased from 52,054 to 86,783, and the notification rate increased from 247 to 370 cases per 100,000 population (Figure 1.4). Young people aged 15 to 29 years comprise 80% of notified cases, and females are disproportionately represented. The notification rates in the 15 to 29 year age range are significantly higher than those observed in the overall population.

Notification rates in young females are highest in those aged 15 to 19 and 20 to 24 years, and in young males rates are highest in those aged 20 to 24 years (Table 1.2).

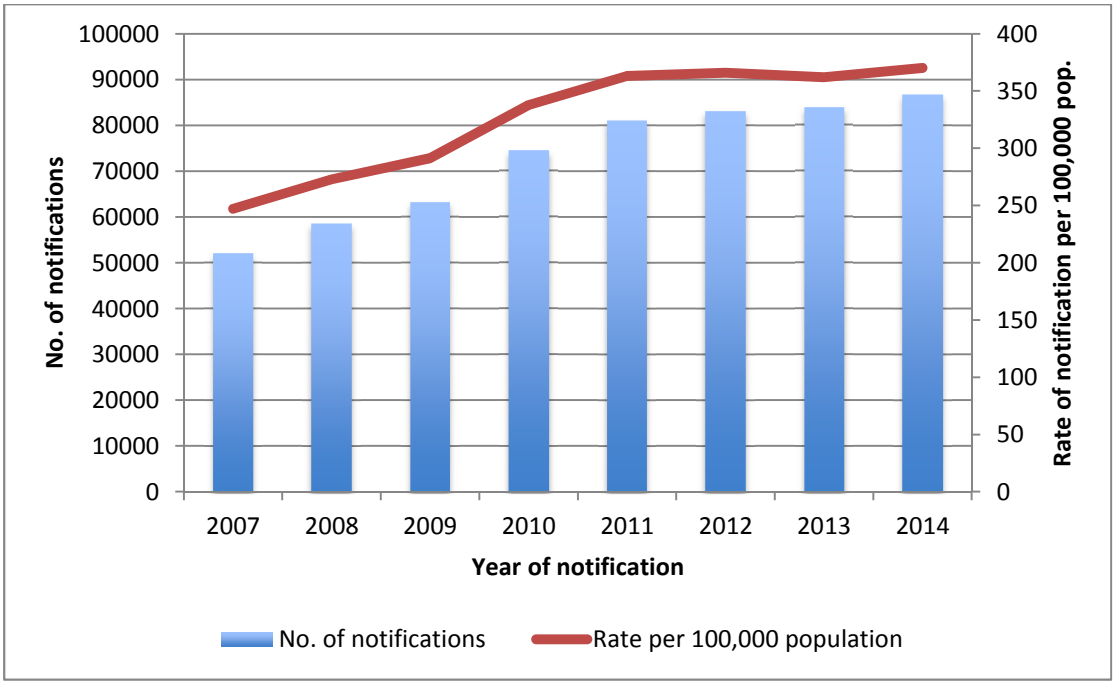

Figure 1.4: Number of notifications and rate per 100,000 population, chlamydial infection, Australia, 2007 to 2014, by year

(Source: Australian Government Department of Health, National Notifiable Diseases Surveillance System, available from: http://www9.health.gov.au/cda/source/cda-index.cfm)

Table 1.2: Chlamydia notification rates, males and females aged 15 to 29 years, Australia, 2007 to 2012^

		Notification rate per 100,000 population					
Age group	**Sex**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
15-19 years	Males	401	488	547	711	740	724
	Females	1383	1566	1718	2064	2299	2202
20-24 years	Males	984	1030	1159	1328	1482	1483
	Females	1595	1722	1788	2044	2228	2283
25-29 years	Males	604	663	671	786	841	866
	Females	688	733	776	814	878	882

^(Source: Australian Government Department of Health, National Notifiable Diseases Surveillance System, available from: http://www9.health.gov.au/cda/source/cda-index.cfm)

1.8 Strategies to control chlamydia

Transmission of chlamydia (as is the case for all sexually transmissible infections) is dependent on the probability of transmission of the pathogen from an infected to a susceptible individual, the rate of contact between infected and susceptible individuals, and how long the infection persists (34), therefore controlling chlamydia requires interventions to reduce each of these factors (8). A range of activities are needed, including: primary prevention, such as patient-level sexual health and relationship education, and population-wide information

and education; promotion of safer sex and condom use; and secondary prevention, including diagnosis and treatment of those with infection (8, 35); and contact tracing and treatment of infected partners (36). Access to quality healthcare is crucial and the availability of a diverse range of services is required to provide comprehensive access to patients with, or at risk of, infection, including those in hard-to-reach population groups (8). .

A particular public health goal for chlamydia control is reducing the duration of infection (8). The asymptomatic nature of the majority of chlamydial infections results in infected persons being less likely to present for healthcare, thereby remaining infectious for a long period and having the potential to transmit the infection to their sexual partners. Timely diagnosis and treatment is therefore an important component of public health strategies (8).

Screening is an additional strategy for early detection and treatment of infected cases. Evidence on the impact of screening on the prevalence of chlamydia infections at a population level is limited, as is the impact of the prevalence of complication in screened women (8). The Australian Government has discussed the possible implementation of systematic screening and testing in the general population as a strategy to control chlamydia, however who to screen, how often, in what setting, and what type of screening program are all questions still under debate (37, 38, 39, 40).

Surveillance activities are an essential component of public health responses to chlamydia infection, to provide information regarding the success of preventive and management activities at the population level (8). Surveillance provides a

mechanism for reporting progress outcomes against strategic goals and supports policy development responsive to emerging trends (41).

1.9 National strategy

In response to the increasing rate of chlamydia notifications, the Australian Government's Third National Sexually Transmissible Infections Strategy (the National Strategy) is designed to focus the healthcare community towards management and control of sexually transmissible infections (STIs), with the goal of reducing the transmission of and morbidity associated with STIs, and the personal and social impacts of infection (30). Specific objectives and actions from the National Strategy include: reducing disease incidence by increasing testing among priority populations; improving surveillance in priority populations; and improving methods of monitoring testing coverage. Priority populations include people aged 15 to 29 years, particularly those aged 15 to 19 years; Aboriginal and Torres Strait Islander people; and people residing in regional and remote locations (30).

Priority actions under the Strategy include increasing the use, access to and accessibility of condoms amongst priority populations; promoting safer sex behaviours and regular testing; and building STI-related knowledge and skills in priority populations (30). Public health initiatives aimed at influencing social determinants of health are an important component (8) as it is recognised that complex behavior change, such as increasing use of condoms, requires an integrated and sustained health promotion and disease prevention approach. The use of peer support and education models to target prevention activities is encouraged (30).

Improving the surveillance of chlamydia, particularly in priority populations, and improving methods to monitor testing coverage is vital to the success of the Strategy (30). Surveillance will support the Strategy by providing data to identify and address emerging issues; evaluate health promotion, prevention, testing and treatment programs and activities to ensure they are effective; support research; and strengthen research translation to guide interventions (30).

1.10 Tasmanian context

Tasmania is an island state of Australia with a population of approximately 512,000 people. Tasmania's unique approach to chlamydia surveillance combines passive and active surveillance. Passive surveillance has been in place since 1997, with active surveillance commencing in 2001.

Under the Tasmanian *Guidelines for Notifying Diseases and Food Contaminants* (42), laboratories are required to notify the Department of Health and Human Services (DHHS) all cases of *Chlamydia trachomatis* infection within five days of diagnosis. DHHS receives the data passively from the laboratory, ie. without any routine follow up or actions to receive the data. Failure of laboratories to notify may attract penalties under the Tasmanian *Public Health Act 1997* (43). Only laboratory confirmed cases of *Chlamydia trachomatis* infection are notifiable. Laboratory definitive evidence is defined as:

Isolation of *Chlamydia trachomatis*

OR

Detection of *Chlamydia trachomatis* by nucleic acid testing

OR

Detection of *Chlamydia trachomatis* antigen (44).

Staff within the Communicable Disease Prevention Unit (CDPU) at the DHHS carry out active surveillance on notified chlamydia cases. On receipt of a laboratory notification, CDPU forward the diagnosing clinician a questionnaire seeking additional information on their patient.

The information collected from laboratories and treating doctors is shown in Table 1.3.

Table 1.3: Data on cases of *Chlamydia trachomatis* collected from laboratories and treating doctors in Tasmania

Data fields collected from laboratories	Data fields collected from treating doctor
Name of disease	Confirmation of case's sex
Laboratory name	Aboriginal or Torres Strait Islander status
Laboratory number	Reason for testing the patient - symptomatic or asymptomatic
Specimen collection date	If asymptomatic: reason for testing
Method of diagnosis	Whether case reports sexual contact with: a/ person(s) of opposite sex only; b/ person(s) of same sex only; c/ person(s) of both sexes; d/ unknown
Surname - first two initials only	Past history of chlamydia infection, if yes, year(s) of previous infection(s)
First name - first two initials only	Whether assistance with contact tracing is required
Date of birth	Any further comments
Sex	
Suburb of residence in Tasmania	
Postcode	
Name of treating doctor	
Address of treating doctor	
Phone number of treating doctor	
Site of infection	

Further description and evaluation of the Tasmanian chlamydia surveillance system is provided as Attachment 1 to this Chapter.

1.11 Research aims

In this thesis, I explore methods of meeting the key surveillance objectives defined under the National Strategy (22) and answering questions pertaining to priority populations. Using the notification data and a unique population-based dataset collected on all chlamydia cases notified in Tasmania between 2001 and 2010, and the results of all laboratory chlamydia testing data conducted from 2001 to 2010 and in 2012 and 2013 in the same population, the specific research aims examined within this dissertation are:

1. To investigate the increasing rates of chlamydia notifications by demographic profile, risk profile and behavioural characteristics, at a whole-population level.
2. To explore the feasibility and usefulness of collecting population-level chlamydia testing data as a routine surveillance tool.
3. To examine the chlamydia testing conducted in Tasmania at a whole population level, to determine test positivity trends.
4. To explore the role and type of healthcare provider in meeting the strategic and clinical guidelines for chlamydia testing.
5. To investigate potential clinical and behavioural influences on the positivity trends found in the chlamydia testing data of at-risk age groups.
6. To report, for the first time in Australia, on the population rate of chlamydia testing and retesting in the priority population aged between 15 and 29 years, to determine whether testing effort is reaching the strategic and clinical guidelines required to reduce chlamydia prevalence.

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1.13 Attachment for Chapter 1: Description and evaluation of the Tasmanian chlamydia surveillance system

1.13.1 Introduction

The following method of describing and evaluating the Tasmanian chlamydia surveillance system was guided by the Center for Disease Control's (CDC) guidelines for evaluating surveillance systems (based on the CDC's Framework for Program evaluation in Public Health) (1). Evidence to inform the description and evaluation was gathered through observation and stakeholder interviews. Stakeholders included the senior surveillance officer and data entry staff within the CDPU at DHHS, laboratory staff, and two groups who regularly use the data to inform their work (Tasmanian Sexual Health Service and Youth Health Services, DHHS).

1.13.2 Objectives of the surveillance system

The objectives of the Tasmanian chlamydia surveillance system are:

- to enable monitoring of trends in infection,
- to enable preventative public health measures to be implemented,
- to enable evaluation of prevention activities; and
- to assist with case management and treatment including contact tracing[2] as required.

[2] Contact tracing is referred to the Tasmanian Sexual Health Service

1.13.3 What is the population under surveillance?

The whole Tasmanian population.

1.13.4 How is the data received and stored?

The data is received on a daily basis following confirmation at the laboratory. Data is received either by fax or printer depending on the electronic set-up of the individual laboratory. At times, data is received by mail. The data is manually entered onto the Tasmanian Notifiable Diseases Database (TNDD) which is protected by password, and hard copy information is stored in locked filing cabinets in locked areas accessible only to authorised staff. The TNDD is a Microsoft Access database. The database allows easy extraction of data for statistical investigation and reporting.

1.13.5 How is the data analysed?

Data are extracted from the TNDD and epidemiology and surveillance staff within the CDPU conducts statistical investigations. Quarterly trends are reported on the DHHS website (2) and to the Tasmanian Sexual Health Service to assist with their planning, quality assurance processes, contact tracing and research. Data analysis also takes place within CDPU due to adhoc requests for data for research purposes and to inform and evaluate DHHS prevention activities.

1.13.6 How is the information disseminated?

Laboratory data is transferred electronically on a daily basis directly to the Communicable Disease Network of Australia (CDNA) through the National Notifiable Diseases Surveillance System (NNDSS). The data transferred does not

include any identifying information (such as surname and first name initials and suburb or postcode of residence). CDNA analyses and reports on the data at a national level (3, 4).

Hard copy case questionnaires are sent to the treating doctors of all cases for collection of additional data and to ascertain the need for assistance with contact tracing. Data is provided electronically to the Tasmanian Sexual Health Service to assist with their planning, quality assurance processes, contact tracing and research.

Deidentified data is also provided to ethics approved researchers on request. The CDPU provides summary data for dissemination to the general Tasmanian public through inclusion on the website of DHHS (2).

The notification process is presented in Figure 1.5

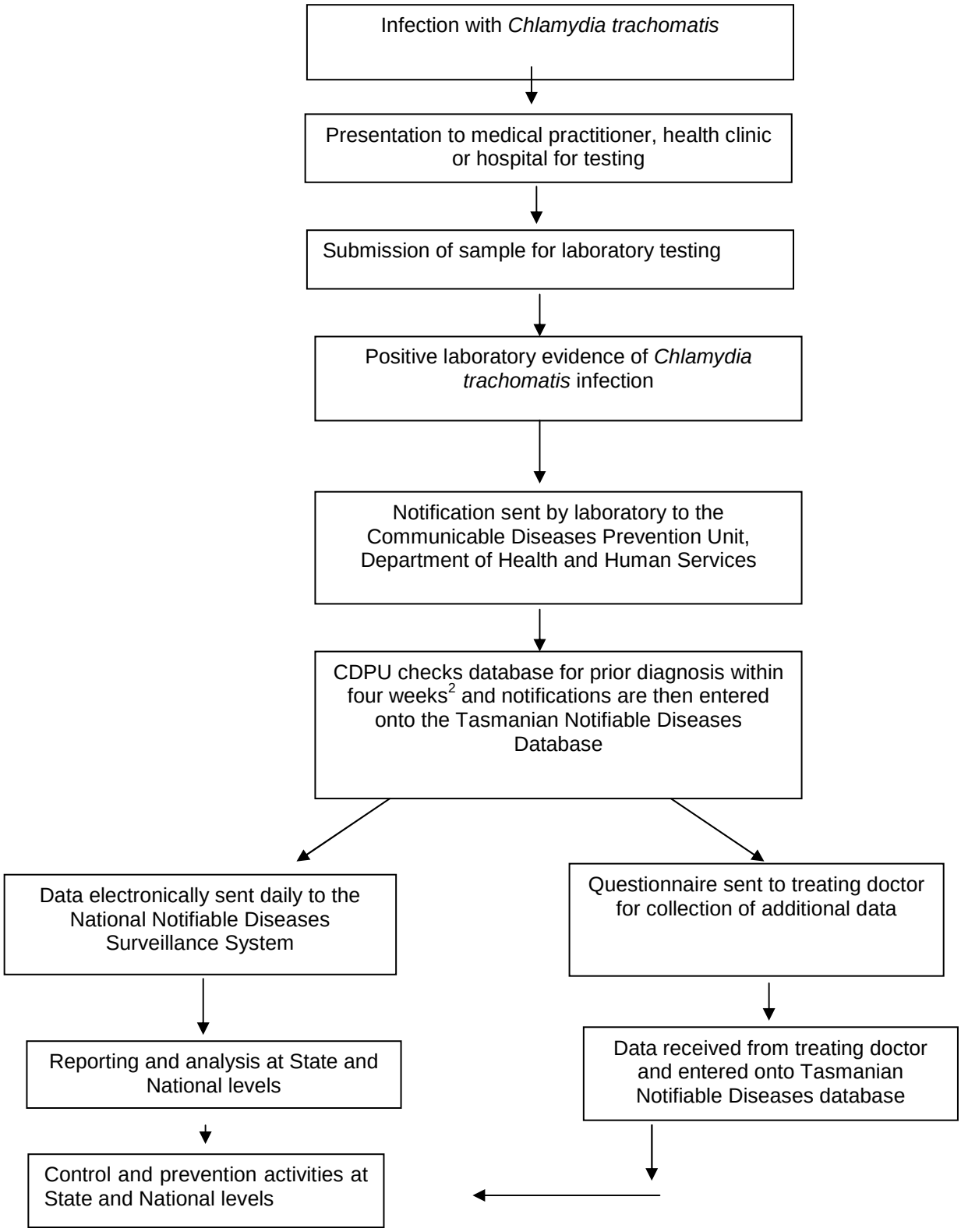

Figure 1.5: Flow chart of the notification process

1.13.7 Usefulness

Information collected by the surveillance system contributes to the prevention and control of chlamydia by enabling active contact tracing through clinicians and the Tasmanian Sexual Health Service. Contact tracing in turn leads to treatment. The data collected is also used to drive policy of the Tasmanian Sexual Health Service including their clinical interventions and practices.

The data collected is used to understand the notification trends and contributes to the measurement of public health strategies and policies surrounding the disease. However, the system has limited ability to monitor, evaluate and inform public health policy and prevention activities and should be interpreted with caution. The surveillance practices do not include collection of data on negative tests (people who were tested for chlamydia but tested negative) (testing data). This limitation can result in bias when planning and evaluating policies and prevention activities, as it does not allow for the impact of fluctuating patterns of testing coverage.

1.13.8 Simplicity

The Tasmanian Notifiable Diseases Database is simple to use and requires limited training to operate. The database is backed up at the end of each day by specialised IT staff. When high volumes of data entry have been completed early in the day, an additional backup is usually conducted by CDPU staff and is a simple process. The system of sending data on a daily basis electronically to the NNDSS is also simple to use.

Only laboratory confirmed notifications are received by CDPU, therefore it is not necessary to check case definitions or follow up laboratory tests to confirm each case. Notifications are only received from laboratories, alleviating any problems associated with multiple levels of reporting. Follow up with notifiers is rarely necessary and any changes, updates and follow-ups are relatively simple to implement.

Receipt of notification faxes and letters is labour intensive and could be improved by the introduction of electronic notification systems. This could also lead to a reduction in hard copy storage and handling for both the CDPU and the notifiers. The system of data entry of each notified case is also highly labour intensive. This could also be alleviated by the introduction of electronic notification systems.

The system of sending out requests to treating clinicians to seek additional data is simple to operate, with letters and forms generated through a standard mail merge. Return rates for enhanced data from clinicians is high, with little follow up necessary. Due to the large volume of chlamydia notifications, the process of active follow up and additional data entry is labour intensive.

Electronic transfer of data to NNDSS allows for easy analysis at a national level. State level analysis and reporting is simple through the extraction of data from the Microsoft Access database into statistical packages.

1.13.9 Acceptability

Surveys conducted with pathology laboratories in Tasmania on the reporting system have indicated a high level of acceptability. As discussed above, the

introduction of electronic notification systems would increase the acceptability even further due to reduced labour intensive systems surrounding the sending of faxes and letters.

The acceptability of the system by clinicians in Tasmania who provide the enhanced data is also high, with a return rate of requests for enhanced data of approximately 85% from 2001 to 2010 (5).

CDPU staff who enter the data find the system simple to operate with easy accessibility to reporting and mail merge facilities. Staff responsible for liaising with laboratories and treating clinicians find the system acceptable. All staff reported concerns with the volume of notifications leading to the system being very high labour intensive.

1.13.10 Sensitivity

The surveillance system for chlamydia meets its objective of monitoring trends in notified cases, but is not able to detect outbreaks or determine the true frequency of the condition in the population. The system cannot pick up every single case due to the large number of asymptomatic and untested cases that are estimated to be in the community.

The laboratory testing methodologies for chlamydia are reliable, with high levels of sensitivity and specificity (6). All cases entered onto the TNDD are laboratory-confirmed and therefore sensitivity issues arising from misclassification of cases are unlikely.

The extent to which public health initiatives and increases in testing for *chlamydia* contribute to increases in notifications is unknown however the system is a useful and accurate measure of notification trends.

1.13.11 Representativeness

Notifications of chlamydia infection to the CDPU are predominantly received on young females between the ages of 16-25 years. As chlamydia is equally sexually spread in males and females (7) this data suggests a significant under screening and underreporting in males. Targeted testing of young women and higher rates of utilisation of health care (8) in this cohort may be fueling these higher notification rates. In Tasmania, Indigenous identifiers are incomplete in chlamydia surveillance data and therefore there are no reliable estimates of whether this population is represented.

1.13.12 Timeliness

The time lag between the onset of the condition and presentation by the case for testing at a doctor or clinic cannot be measured by the surveillance system. The timeliness between specimen collection to information becoming available for public health action is acceptable and consistent with the objectives of the system. A review undertaken in 2005 showed that the median number of days that it took from specimen collection to data entry at CDPU was 5 days. This timeframe included testing at the laboratory and notification by the laboratory to the CDPU.

The review also found that the median time taken for the CDPU to send requests to clinicians for enhanced data was one day. The median time it took for the

enhanced data to be received back from the clinicians was 8 days (D Coleman, Senior Surveillance Officer, DHHS, personal communication).

1.13.13 Resources

Prior to data entry of the chlamydia notification, a check of the database is undertaken to ensure a notification for the same person has not been received in the prior four weeks, and this quality assurance process increases the data entry time. The age of cases is also considered prior to data entry and any questionable cases are brought to the attention of the senior surveillance officer for confirmation and follow-up where necessary.

Data is entered in batches, and once entered a mail merge is conducted for collection of enhanced data including the production of a form letter. A pre-paid envelope is also included when sending the enhanced data request to clinicians, which adds to the time it takes to send out the request, but is considered to increase their return rate. The data entry of notifications of chlamydia infection is incorporated amongst all surveillance data entry and it is difficult to assess the amount of full time equivalent employee's time taken. It is estimated that each chlamydia notification takes approximately 10 minutes to manage, including data entry and sending of enhanced data requests. This time does not include any time spent on analysing or interpreting the data.

Most contact tracing is conducted either by the patient's clinician or through the Tasmanian Sexual Health Service's three regional health centres. Approximately 1% of contact tracing is conducted by the CDPU and therefore requires very little resources.

1.13.14 Discussion

Tasmania's chlamydia surveillance system is simple to use however it would benefit from the introduction of electronic laboratory reporting to alleviate the labour intensive nature of the work under current practices.

The surveillance system is able to assist with case management and treatment including contact tracing, due to the active system of follow up of all treating doctors. This is also labour intensive.

The system is able to monitor trends in notified cases, however is not able to monitor population trends in infection due to the large number of asymptomatic and untested cases that are estimated to be in the community.

The surveillance system would be greatly improved if it were able to collect data on negative tests. This would allow for general adjustments of testing practices when monitoring trends for evaluation of prevention activities and other public health measures.

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Chapter 2

Chlamydia trachomatis in Tasmania 2001-2007: rising notification trends

Stephens N, O'Sullivan M, Coleman D, Shaw K. *Chlamydia trachomatis* in Tasmania 2001-2007: rising notification trends. *Aust NZ J Public Health* 2010; 34: 120-125.

Chapter 2 — *Chlamydia trachomatis* in Tasmania 2001-2007: rising notification trends

2.1 Preface

Although chlamydia is a notifiable disease in all Australian states and territories, Tasmania is the only jurisdiction to systematically conduct follow-up of the treating doctor of all notified cases for the purpose of collecting additional surveillance data. Smaller studies have shown that additional surveillance can provide valuable epidemiological information useful in focusing chlamydia control efforts and in defining the burden of chlamydia in the Australian community.

In this study, we analyse the unique dataset collected on chlamydia infections in Tasmania and provide a statistical comparison of rates in population sub-groups observed over the time period January 2001 to December 2007.

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Data from this analysis have also been published in *Sexual Health* (Shaw K, **Stephens N**, Coleman D, O'Sullivan M 2009) and included in Appendix A.

2.2 Abstract

2.2.1 Objectives

To investigate trends in notification rates of *Chlamydia trachomatis* in Tasmania, Australia, by population sub-groups, from 1 January 2001 to 31 December 2007.

2.2.2 Methods

An enhanced surveillance dataset was used to supplement case notifications. Rates based on age group were analysed by sex, geographic region, indigenous status, sexual exposure, reason for testing and healthcare provider.

2.2.3 Results

In all age groups, the notification rate increased steeply. The highest rates were seen in the ages 15-24 years; this age group represented 15% of the population but accounted for 74% of the chlamydial notifications. The increased rates in females aged 15-24 years and males 15-19 years in Tasmania were larger than the increases observed nationally. Rates were consistently higher in urban areas. Females were more likely to have been tested as a result of screening, and males were more likely to have been tested when presenting with symptoms or as a result of contact tracing. The majority of cases reported sexual exposure with opposite sex partners only.

2.2.4 Conclusions

This study highlights the increasing significance of chlamydial infection as a public health issue, the gender differences in health-seeking behaviour, and the discrepancies in testing patterns. These findings will assist with the design of health promotion programs.

2.3 Introduction

Genital infections with *Chlamydia trachomatis* (chlamydia) are a major cause of disease and morbidity internationally, and a steady rise in rates has been recognised in the past two decades (1, 2). The World Health Organization (WHO) estimates that the global disease burden for treating chlamydia patients is $10 billion per year (3).

In Australia, chlamydia is the most common sexually transmissible bacterial infection(4) and the rate of notifications has increased each year since surveillance of the condition commenced in 1991 (5, 6). Nationally, notification rates have been consistently highest in the age groups 15-19 years and 20-24 years, and these two age groups have also experienced the steepest increases in notification rates over time.

Between 2001 and 2007 in Australia, the notification rates in females aged 15-19 years rose from 568 to 1,348 cases per 100,000 population, and in females aged 20-24 years the notification rates rose from 667 to 1614 cases per 100,000 population. In males aged 15-19 years, notifications rose from 149 cases per 100,000 population in 2001 to 387 cases per 100,000 population in 2007, and for males 20-24 years the rates increased from 375 to 991 cases per 100,000 population (7). The costs of chlamydia infection for the Australian healthcare system have been estimated to be between $90 million and $160 million per year (8). Chlamydia infection can lead to significant health complications, including pelvic inflammatory disease, endometritis and ectopic pregnancy in women, and epididymitis and reactive arthritis in men (2, 9-11). Chlamydia can also result in infertility in both males and females (12-

15). A large proportion of chlamydia infections are asymptomatic (1, 8) and as a result often remain undiagnosed, increasing the likelihood of health complications (9-11) and adding to the spread of infection (16).

Screening has been recognised as a cost- effective method of reducing the prevalence of chlamydia (8, 17-19), and chlamydial infection meets the WHO criteria for a screening program (8, 20). The Australian Government's *National Sexually Transmissible Infection Strategy 2005-2008* (21) identified chlamydia as a priority and as a result the Australian Government plans to implement systematic screening and testing in the general population. Who to screen, how often, in what setting, and type of screening program are all questions still under debate (19, 22-24). Although chlamydia is a notifiable disease in all Australian States and Territories, Tasmania is the only jurisdiction to conduct follow-up on all notified cases for the purpose of collecting enhanced data. Smaller studies have shown that enhanced surveillance can provide valuable epidemiological information useful in focusing chlamydia control efforts (8, 25) and in defining the burden of chlamydia in the Australian community (6). Since 2005, enhanced STI surveillance data has been collected nationally for gonococcal infection, donovanosis and syphilis (26), and the enhanced data collected on chlamydia in Tasmania is fully compatible with the data collected nationally for those infections.

Our study analyses the unique dataset collected on chlamydia infections in Tasmania and provides a statistical comparison of rates in population sub-groups observed over the time period January 2001 to December 2007.

2.3.1 Methods

2.3.1.1 Case definition

For the purposes of this study, a case was defined as a person with sexually acquired, laboratory confirmed *Chlamydia trachomatis* (chlamydia) infection with specimen collection date from 1 January 2001 to 31 December 2007 inclusive. Cases with ocular infections were excluded. Cases with a laboratory confirmed test for chlamydia within the previous four weeks were also excluded. Laboratory evidence was defined in accordance with the Communicable Diseases Network of Australia guidelines (27) as:

- isolation of C. trachomatis from cell culture;
- detection of C. trachomatis by nucleic acid testing; or
- detection of C. trachomatis antigen.

2.3.1.2 Data collection and management

We identified our cases from the Tasmanian Notifiable Diseases Database (TNDD) held within the Communicable Diseases Prevention Unit (CDPU) in the Department of Health and Human Services (DHHS), Tasmania. Laboratories are obliged under the Public Health Act Tasmania 1997 to provide core data on all laboratory-confirmed cases of chlamydia to the CDPU (29) and treating clinicians were actively followed up by the CDPU for collection of the Tasmania-specific enhanced data by a standard one-page mailed questionnaire (Table 2.1). All notified laboratory data was entered into the TNDD in preparation for reporting to the Commonwealth Department of Health and Ageing, and the Tasmanian enhanced data collected from clinicians was entered into a separate area of the TNDD created for the NNDSS STI surveillance dataset (26).

Data collected before 2005 was retrospectively coded and entered into the enhanced dataset.

Table 2.1: Data collected on *Chlamydia trachomatis* infection in Tasmania

Data Notified by Laboratories	**Data Collected from Clinicians**
Disease code	Confirmation of case's sex
Laboratory name	Indigenous status
Laboratory number	Reason for testing the patient – symptomatic or asymptomatic
Specimen collection date	If asymptomatic, reason for testing
Surname – first two initials only	Whether case reports sexual contact with: a/ person(s) of the opposite sex b/ person(s) of the same sex c/ person(s) of both sexes d/ unknown
First name – first two initials only	Past history of chlamydial infection, if yes, year(s) of previous infection(s)
Date of birth	Whether assistance with contact tracing is required
Sex	Whether case reports undertaking commercial sex work within the last twelve months
Region of residence in Tasmania	Any further comments
Name of treating clinician	
Site of infection	

2.3.1.3 Analysis

Rates of notifications based on age group were analysed by sex, geographic region, indigenous status, sexual exposure, reason for testing and healthcare provider. Healthcare provider data was coded by one of the authors (DC), using pathology laboratory reports, the data collected on clinical facility type, and an up-to-date database of clinicians held within the TNDD (28). The geographical classification system was based on the Australian Standard Geographical Classification system (Australian Bureau of Statistics) (30). For analyses, cases classified as rural or regional were categorised as non-urban cases, and cases classified as metropolitan were categorised as urban cases.

Population denominators were derived from the estimated resident population of each collection district obtained from the Australian Bureau of Statistics by sex and five-year age groups for each year of data collection (2001-2007). Seven age groups were used for the analyses: 10-14 years, 15-19 years, 20-24 years, 25-29 years, 30-34 years, 35-39 years and 40+ years.

Data were extracted into a Microsoft® Excel spreadsheet and analysed using Stata® version 10.0 (Stata Corporation, College Station, TX, US) (Stata). Exposures were expressed as dichotomous variables and crude rate ratios (RR) with 95% confidence intervals (CI) were calculated.

2.3.2 Results

2.3.2.1 Incidence

Between 1 January 2001 and 31 December 2007 inclusive, there were 5,072 cases of chlamydia notified in Tasmania of which 99.6% (n=5,053) were isolated

by nucleic acid testing with the remainder (0.4%) detected by antigen testing. The number of notifications increased steeply each year from 2001 to 2007 in both males and females.

The 1,116 notifications received in 2007 represented an increase of 202% over the number of reported cases in 2001 (n=369). Female notifications accounted for 67% of all cases (Figure 2.1). Enhanced data was collected for 85% of notified cases (n=4,301) with a response rate consistent with the core notification data set by both gender and age group.

The median age of female cases was 20 years (range 13 to 61 years) and the median age of male cases was 23 years (range 14 to 69 years). In cases aged less than 30 years, female notifications greatly exceeded male notifications. Eighty per cent of female cases (n=2,717) were aged between 15 and 24 years. This age group of female cases made up 54% of the total of all notifications received over the study time period. Sixty-two per cent of male cases were aged between 15 and 24 years (n=1,041).

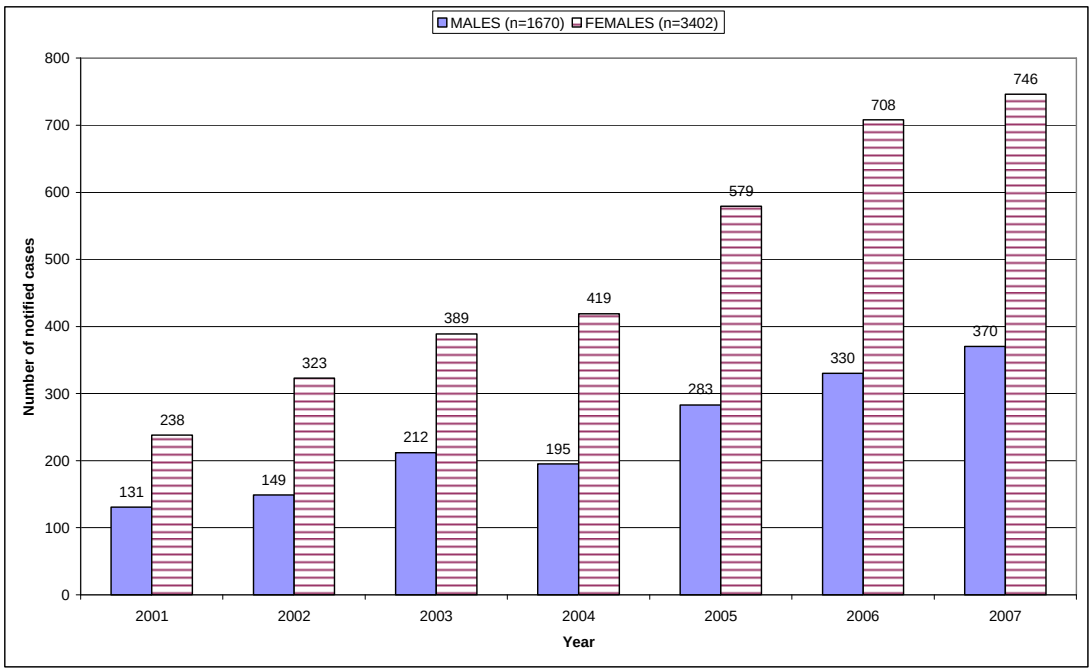

Figure 2.1: Chlamydia notifications, Tasmania, 2001-2007 by sex

2.3.2.2 Notification rates by age groups

In all age groups, the notification rate per 100,000 population increased steeply over the period 2001 to 2007. In age groups under 35 years, in both sexes, the increases were significant.

The highest rates for both sexes were seen in the age groups 15-19 years and 20-24 years. Between 2001 and 2007, persons aged 15-24 years represented 15% of the Tasmanian population (30), this same age group accounted for 74% of the Tasmanian chlamydial notifications.

Between 2001 and 2007, the notification rate for females in the 15-19 year age group increased by 1,127 cases per 100,000 population (195%, $p<0.01$), and the rate in females aged 20-24 years increased by 1,086 per 100,000 population (167%, $p<0.01$). In males, increases of 287 per 100,000 population (15-19 year age

group) (228%, $p<0.01$) and 472 per 100,000 population (20-24 year age group) (126%, $p<0.01$) were observed.

2.3.2.3 Notification rates by urban/non-urban status

The rate of chlamydia notifications per 100,000 population was consistently higher in urban areas than in non-urban areas. The rates for males and females in both geographic categories increased steeply over the seven-year period 2001 to 2007. Urban rates increased by 213 cases per 100,000 population for females and by 109 cases per 100,000 population for males; and non-urban rates increased by 239 cases per 100,000 population for females and 107 cases per 100,000 population for males (Figure 2.2).

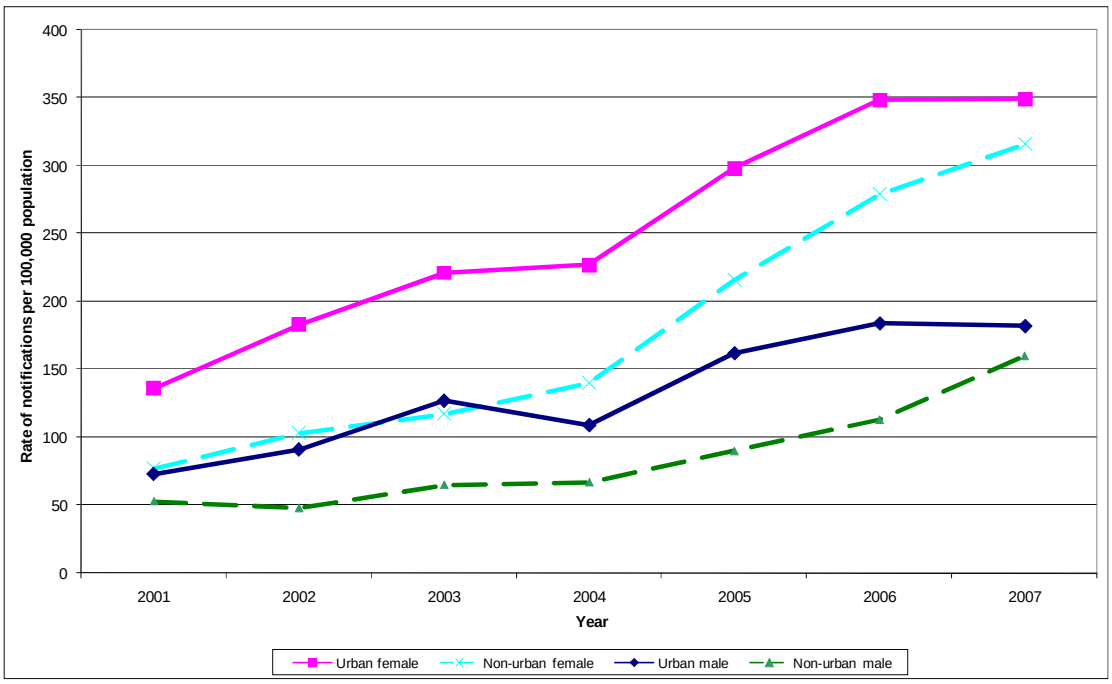

Figure 2.2: Rates of chlamydia notifications per 100,000 population, by urban status and sex, Tasmania, 2001-2007

2.3.2.4 Indigenous status

Data on indigenous status was collected for 71% (n=1196) of male cases and 68% (n=2319) of female cases. Two per cent reported Aboriginal or Torres Strait Islander origin. Notification patterns were found to be the same as in the general population.

2.3.2.5 Commercial sex work

Data on whether the case reported undertaking commercial sex work within the 12 months prior to infection with chlamydia was received for 532 (32%) of notified male cases and 1077 (32%) of notified female cases. One male case and nine female cases were reported as having undertaken commercial sex work during that time period.

2.3.2.6 Reason for testing

Females were more likely to have been tested for chlamydia infection as a result of screening, and males were more likely to have been tested for chlamydia when presenting with symptoms or as a result of contact tracing (Table 2.2).

Table 2.2: Reason for testing by sex, *Chlamydia trachomatis* notifications Tasmania 2001-2007

Reason for testing	Females (n=2894)	Males (n=1408)
Symptomatic presentation	1081 (37%)	737 (52%)
Contact tracing	376 (13%)	455 (32%)
Screening	1437 (50%)	216 (15%)

2.3.2.7 Sexual exposure

The majority of cases reported sexual exposure with opposite sex partners only. Cases aged 35 years and older were more likely to report sexual exposure with same sex partners and less likely to report opposite sex partners than the younger age groups (Table 2.3).

Table 2.3: Sexual exposure by age group, *Chlamydia trachomatis* notifications Tasmania 2001-2007

Sexual exposure	**10-14 yrs (n=23)**	**15-19 yrs (n=962)**	**20-24 yrs (n=1105)**	**25-29 yrs (n=390)**	**30-34 yrs (n=141)**	**35-39yrs (n=75)**	**40+ yrs (n=73)**
Opposite sex only	22 (96%)	929 (97%)	1064 (96%)	363 (93%)	133 (94%)	64 (85%)	62 (85%)
Same sex only	0 (0%)	30 (3%)	40 (4%)	24 (6%)	8 (6%)	10 (13%)	8 (11%)
Both sexes	1 (4%)	3 (0%)	1 (0%)	3 (1%)	0 (0%)	1 (1%)	3 (4%)

2.3.2.8 Healthcare provider

Most cases were diagnosed by a general practitioner, however females were significantly more likely than males to be diagnosed through a public hospital (RR 1.2; 95% CI 1.1-1.3) or a family planning clinic (RR 1.4; 95% CI 1.3-1.4), and less likely than males to be diagnosed through a general practitioner (RR 0.8; 95% CI 0.8-0.8) or sexual health clinic (RR 0.7; 95% CI 0.7-0.8) (Table2. 4).

Table 2.4: Type of healthcare provider by sex, *Chlamydia trachomatis* notifications Tasmania 2001-2007

Type of healthcare provider	Females, n (%)	Males, n (%)
General Practice	2425 (71%)	1399 (84%)
Family Planning Clinic	409 (12%)	40 (2%)
Sexual Health Clinic	197 (6%)	192 (11%)
Public hospital	156 (5%)	35 (2%)
Private hospital	3 (0%)	4 (0%)
Private obstetricians/gynaecologists	212 (6%)	0 (0%)

2.3.3 Discussion

Our study is the first in Australia to provide a comparison of chlamydia notification rates by subgroups derived from a population-based enhanced dataset collected over a seven-year period, with a valid high response rate.

We found the majority of notifications were in people aged 15-24 years, with an over-representation of females in this age group. This peak can be interpreted in a number of ways including, greater utilisation of healthcare by females of this age, targeted and opportunistic testing within the cohort, and a cohort with high susceptibility to infection. Our results highlight the need for targeting safer sex interventions for this age group.

As chlamydia is equally transmitted in males and females (6), our data suggests both significant under-screening and under-reporting in males. Strategies to improve screening in men need to be developed and continues to be an area in need of further research. Unlike females, males do not routinely consult a doctor

about their sexual health and contraception (31) unless symptomatic or alerted through partner notification systems. Awareness within general practice and emergency departments (32) of opportunistic screening of males who present acutely for other reasons would help boost screening, particularly given the ease of screening based on urine sampling. In general, however, males, particularly healthy young males in the age groups at most risk, access healthcare infrequently. The Australian Institute of Health and Welfare has found that males visit doctors consistently less than females (33), therefore it would be advantageous to consider extending screening into non-medical settings, such as sporting clubs, as proposed by Gold et al (34).

Notification rates in males were highest in the cohort of 20-24 year olds and may be illustrative of the concept of age bridging (35). Age bridging in this context is when a male has a female sexual partner who is two or more years younger. Jennings et al (35) found that this group of males often had multiple partners within short timeframes and were likely to use drugs and alcohol in relation to sexual intercourse. The available enhanced data from Tasmania does not confirm this behaviour but suggests a further area of research.

The 2009 Guidelines for preventive activities in general practice from the Royal Australian College of General Practitioners (RACGP) suggests that all sexually active females aged under 25 years, and all sexually active people aged 15-25 years with a recent change in sexual partner or with a pattern of inconsistent or no condom usage, should be screened for chlamydial infection every 12 months (36). Concentration on the under 25 year old females is reinforced by the Tasmanian dataset.

The increase in notification rates in Tasmania in females in the age groups 15-19 years and 20-24 years and in males in the age group 15-19 years were larger than the increases that have been observed nationally (7). This would suggest that systematic screening in Tasmania should encompass people in the age range 15-24 years, however jurisdictional differences may necessitate States and Territories establish tailored screening programs based not only on notification rates but also on rigorous modelling of potential strategies.

The finding that older cases were more likely to report sexual exposure with same sex partners may reflect a real difference across age groups, or a reluctance of younger cases to disclose their sexual history to their treating medical practitioner. If disclosure is an issue, this has implications for effective contact tracing. Patient referral is used for almost all contact tracing (37), and patient reluctance has been found previously to be the most common barrier to contact tracing for sexually transmitted infections (38).

Although the majority of cases had their infection diagnosed through a general practitioner, the range and the differences between the sexes and across age groups in choice of healthcare provider highlights the importance of the availability of a variety of services. This is particularly relevant to ensure that type of healthcare provider does not become an obstacle to testing for young people at highest risk of infection (39).

Of note from our data is the small number of notifications that have come from hospitals. Chlamydia is associated with adverse pregnancy outcomes such as risk of pre-term delivery and premature rupture of the membranes (40) and

puerperal infections (41). The RACGP suggests chlamydial screening be considered for pregnant women who are considered to be at increased risk (42). Chen et al's (43) recent study supports this recommendation. They found that 72% of the infections detected in their study would have been found if screening had been restricted to all women under 20 years of age and all women aged 16-25 years who reported more than one sexual partner in the previous 12 months. While some of the general practice notification figures may represent antenatal screening, the lack of hospital-based notifications highlights the need to consider routine chlamydia screening in hospital-based antenatal settings, particularly in the cohorts aged 15-24 years and those reporting more than one sexual partner.

We detected consistently lower notification rates of infection in non-urban areas, a pattern observed elsewhere (2). Our finding warrants further investigation, as it is not known whether it reflects inequitable access to chlamydia testing, a difference in health- seeking behaviours, or a true difference by geography.

The type and sensitivity of diagnostic tests was constant over the study time period and, therefore, was unlikely to have influenced the increase in notification rates. Increased notifications could, however, be related to increased testing (17) and an exploration of the testing effort over the time period of the study is needed to assess this association.

Excluding cases with a confirmed test within the previous four weeks point minimised the risk of including retests. Hosnefeld et al (44) conducted a

systematic review of the literature that examined reinfection with chlamydia and gonorrhoea and found that, in all but two of the studies included, reinfection was defined as a positive test greater than two weeks after an initial positive. In Australia, the Reinfection Period Convention Project conducted in New South Wales, developed conventions for reinfection periods based on best available evidence. The project found that 30 days after primary infection with chlamydia was the appropriate time period for subsequent positive diagnoses to be considered new episodes of infection (45).

A limitation of our study is that enhanced data was not collected for 15% of cases. However, there was no difference found in the age, sex or geographical location of the cases for whom we collected enhanced data and for whom we did not, and therefore the risk of selection bias is minimal.

The majority of notifications reported in our study were based on tests conducted as a result of symptomatic presentation or screening and as a large proportion of chlamydial infections remain asymptomatic, it is likely that our notification rates are an underestimation of the true rates. A formal epidemiological population-based prevalence study in Tasmania would allow a more accurate assessment of the rates and provide further evidence to inform planning of appropriate health services.

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Chapter 3

Improving public health surveillance of chlamydia: analysis of population-level positivity trends

Chapter 3 — Improving public health surveillance of chlamydia: analysis of population-level positivity trends

3.1 Preface

The previous chapter examined the trends in notification data by population sub-groups. In this chapter, we compare the chlamydia notification trends from 2001 to 2010 to laboratory testing data from the same time period, to: examine the usefulness of reporting positivity trends; determine whether observed increases in notifications were an artefact of testing practices; and improve understanding of testing practices of healthcare providers.

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3.2 Abstract

3.2.1 Background

Chlamydia remains Australia's most frequently notified communicable disease, however interpretation of notification data is difficult without knowledge of testing practices. This study aimed to examine the usefulness of reporting positivity trends; determine whether observed increases in notifications were an artefact of testing practices; and improve understanding of testing practices of healthcare providers.

3.2.2 Methods

We compared Tasmanian chlamydia laboratory tests and notification data from 2001 to 2010. Notifications were analysed by age group, sex, healthcare provider and region; and tests were analysed by positivity, age group, sex, region and laboratory.

3.2.3 Results

Notification rates increased in males (381%) and females (410%); with highest rates in males and females aged 15-24 years. Test numbers increased in males (277%) and females (168%), with largest increases in the age groups between 15-29 years (males 338%, females 180%). Positivity increased in males (114%) and females (50%) with the most significant increases in males and females aged 15-19 years (150%, 94%) and 20-24 years (94%, 83%). Test positivity was highest, and number of tests lowest, in the northwest region. General practitioners notified 75% of cases. Private laboratories conducted 72% of tests.

3.2.4 Conclusions

Analysis of population-level chlamydia positivity improved our interpretation of trends in the notification data. After allowing for testing effort, we found a significant increase in chlamydia infections in young people. Reporting positivity trends is a more useful method of surveillance than reporting trends in notified cases. We recommend health authorities report positivity trends whenever possible, to improve the ability to develop, monitor and evaluate prevention and control activities.

3.3 Introduction

Chlamydia trachomatis (chlamydia) is associated with significant short and long-term morbidity, including adverse reproductive outcomes and increased transmission of other sexually transmissible infections; and the burden of disease related to chlamydia infections impacts heavily on health services (1). Chlamydia is Australia's most frequently notified communicable disease; notifications have been increasing steeply since it first became notifiable in 1991, and the highest notification rates are in young people aged between 15 and 29 years (2). In Tasmania, increases in notification rates in these age groups have been reported as greater than those observed nationally (3).

To enable planning of public health priorities and to inform policy to reduce the incidence of chlamydia, Australia's National Sexually Transmissible Infections Strategy (NSTIS) highlights the importance of understanding the chlamydia epidemic through analysis of surveillance data (4). It is difficult, however, to interpret the epidemiology of chlamydia from surveillance data alone (5-7). Surveillance data reported to health departments does not include negative test results and denominator data is essential to be able to understand whether fluctuations in rates of notifications reflect testing practices (5, 7, 8). Analysis of both positive and negative tests can more accurately describe trends, improve interpretation of the epidemiology, and therefore improve the ability to plan, monitor and evaluate prevention and control programs (5, 8).

Analysis and reporting of laboratory testing data is being used increasingly as a surveillance tool both internationally and within Australia. In England, the Chlamydia Testing Activity Dataset (CTAD) collects chlamydia data from all

National Health Service (NHS) and NHS-commissioned laboratories. The purpose of CTAD is to monitor population screening coverage, and the trends in the proportion of positive tests. England's priority is to reduce the incidence of chlamydia, and measuring the proportion of the target population tested each year is a crucial component of its program (9, 10). In the United States, the Centers for Disease Control and Prevention (CDC) reports test trends in its annual Sexually Transmitted Disease Surveillance reports to assist in monitoring the burden of the disease and guide screening programs (11). Norway implemented a laboratory based surveillance system in 2005 whereby they collect the total number of chlamydia tests performed and the number of diagnosed cases once a year from all laboratories, and in 2007 improved their system to collect additional information on age, gender and geography in order to better interpret trends (12). In New Zealand, chlamydia is not notifiable and measurement of trends in laboratory tests and positivity is used for surveillance purposes (13).

In Australia, the proportion of chlamydia tests positive (positivity) has been reported in a number of studies and reviews (14-17) and sentinel surveillance systems have contributed importantly to the surveillance of chlamydia by collecting and analysing testing and positivity trends (5, 6, 18). The Australian Collaboration for Chlamydia Enhanced Sentinel Surveillance (ACCESS) group and others recommend the ongoing monitoring of positivity to better understand trends in chlamydia notifications (5, 11, 12).

Although general practitioners (GPs) notify the majority of chlamydia cases (3) and the Royal Australian College of General Practitioners recommends annual

screening of all sexually active young people aged less than 15-29 years (particularly those: aged under 20 years, of Aboriginal or Torres Strait Islander origin, who report inconsistent or no condom usage, or a recent change in sexual partner) (19); low chlamydia testing rates in young people who attend GP practices have been reported (20). The NSTIS has prioritised support for GPs to promote opportunistic sexual health checks (4), and the level of testing for chlamydia in GP practices in Tasmania needs investigation (20).

The aims of this study were to:

- Examine the usefulness of collecting population-level chlamydia testing data as a surveillance tool;
- Compare Tasmanian population chlamydia positivity trends with the notification data from 2001 to 2010, to determine whether the steep rise in notifications reflected a true increase in infections, or whether the rise was an artefact of testing practices; and
- Improve understanding of chlamydia testing practices of Tasmanian health care providers.

3.3.1 Methods

We identified our cases from the Tasmanian Notifiable Diseases Database (TNDD) held within the Communicable Diseases Prevention Unit (CDPU) in the Department of Health and Human Services (DHHS), Tasmania. Laboratories are required under the *Public Health Act Tasmania 1997* to notify all laboratory-confirmed cases of chlamydia to the DHHS (21). A case in our study was defined as a person aged 10 years and over with chlamydia infection detected by nucleic

acid testing or direct immunofluorescence, between 1 January 2001 and 31 December 2010. Cases notified with ocular infections or with a laboratory confirmed test for the same disease within the previous four weeks were excluded. Notifications were analysed by age group, sex, geographical region of residence (south, north, north-west)(22) and healthcare provider.

Extensive discussions were held with all pathology laboratories in Tasmania to highlight the importance of collecting denominator data in order to improve understanding of the trends in chlamydia notifications. The researchers acknowledged the sensitivities associated with the commercial interests of the laboratories, and it was agreed by all parties that laboratory data would be combined by the researchers, and that the testing conducted by individual laboratories would not be reported or shared with any other party. Laboratories agreed to provide the age, sex, postcode of residence and result of test for all chlamydia tests generated by Tasmanian-based clinicians from 2001 to 2010. Where indicated, post treatment tests conducted within the same month were excluded. Testing data were analysed by: result of test, age groups, sex, geographical region of case residence, and type of laboratory (private or public). Positivity was calculated by dividing the total number of positive tests by the total number of tests conducted.

This research was undertaken in accordance with Tasmania's Personal Information Protection Act 2004 (23), in particular Schedule 1 of the Personal Information Protection Principles contained within the Act. In addition, the release of the de-identified dataset was authorised by the Director of Public Health under the provisions of the *Public Health Act 1997* (21). Laboratories de-

identify laboratory reports prior to notifying DHHS of confirmed cases of chlamydia. Only the first two initials of the first and last name (2x2 name codes) of cases of chlamydia are notified, with addresses removed and inclusion of only the postcode of residence. De-identified data fields relevant to this analysis were extracted from the TNDD by author 2 for the purposes of this analysis. Laboratory testing data did not include 2x2 name codes.

All data were extracted into Microsoft Excel spreadsheets and analysed using Stata version 12.0 (Stata Corporation, College Station, TX, US) (Stata). We conducted chi-squared tests to analyse testing and positivity trends, and linear regression to analyse notification trends.

3.3.2 Results

3.3.2.1 Notifications

Chlamydia notifications increased steadily over the 10-year study period, with 10,024 cases notified in total. Female cases made up 66% (n=6603) of notifications. Eighty-eight percent (n=8,828) of notified cases were aged between 15 and 29 years. The median age of male cases was 22 years (range 14 to 82 years, IQR 21-24 years); the median age of female cases was 20 years (range 12-63 years; IQR 18-24 years).

General Practitioners notified 75% (yearly range 72-77%) of cases (82% of male, 71% of female) and 97% of the GP notified cases were diagnosed in private laboratories. In males, sexual health clinics notified 13% of cases, public and private hospitals and family planning clinics combined notified less than 6%. Family planning clinics notified 11% of female cases, sexual health clinics 7%,

public hospitals and other clinics 5% each, and private hospitals <1% of female cases. Notifiers, other than GPs, utilised public health laboratories for 78% of their testing.

In males, the notification rate increased from 66 to 318 cases per 100,000; in females, the notification rate increased from 115 to 586 cases per 100000 (both P_{trend}<0.001). Notification rates were highest in females aged 15 to 19 years, followed by females aged 20 to 24 years, and males aged 20 to 24 years (Figures 3.1 and 3.2).

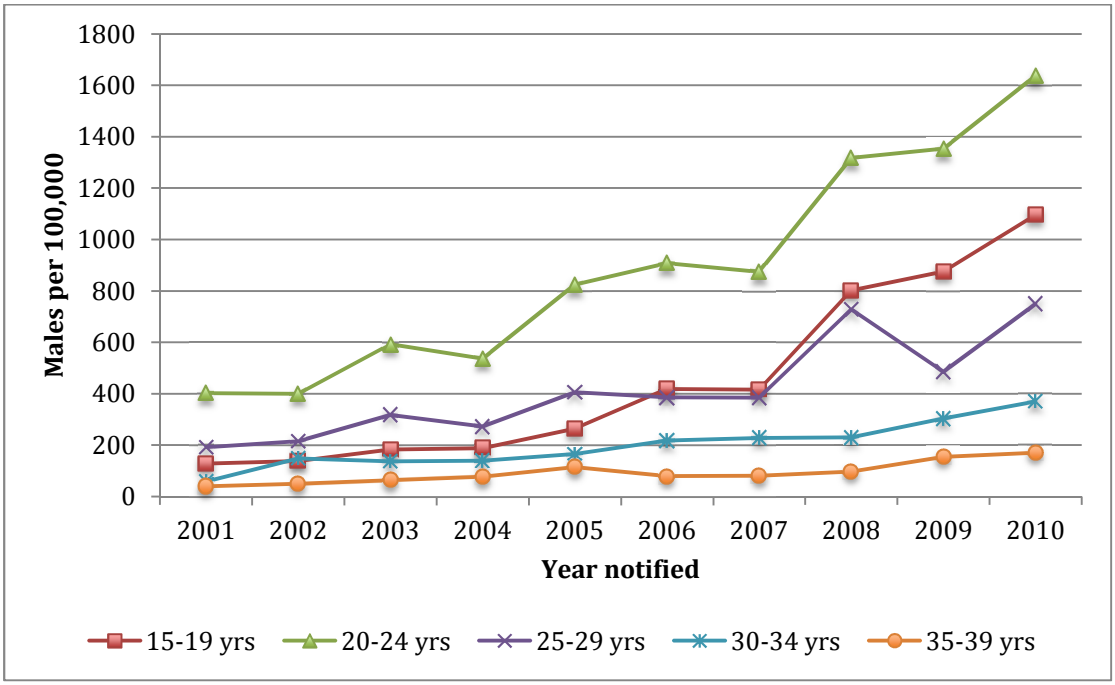

Figure 3.1: Chlamydia notification rates in males, by age group, Tasmania 2001 to 2010

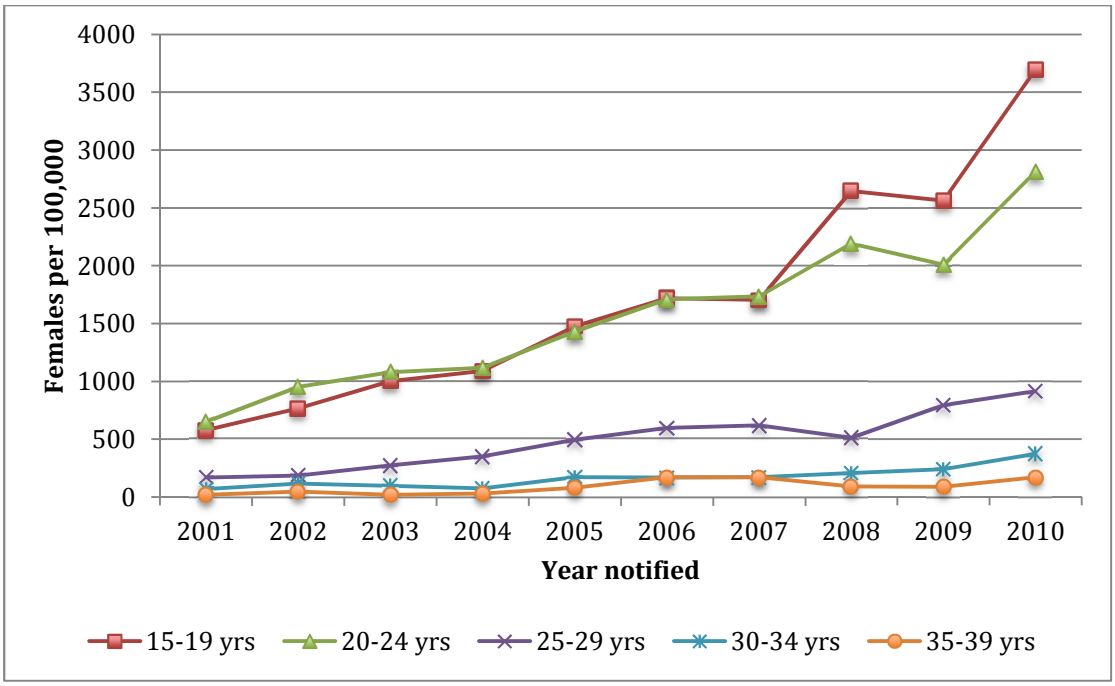

Figure 3.2: Chlamydia notification rates in females, by age group, Tasmania 2001 to 2010

3.3.2.2 Testing

There were 138,396 tests for chlamydia conducted over the study period; the majority were nucleic acid tests (99%). The remainder (1%) were direct immunofluorescence tests which were performed at a single laboratory from 2001 until phased out in 2006. Tests with indeterminate results (0.7%) were excluded. Age and sex was available for 99.8% of tests. The median age of males tested was 27 years (IQR 22-37 years) and of females was 24 years (IQR 20-32 years); 77% (n=106,740) of tests were conducted in females; 70% (n=82189) of female and 58% (n=18,360/31,656) of male tests were conducted in people aged 15 to 29 years. The proportion tested aged between 15 and 29 years remained consistent in females over the 10 years (range 68%-72%); in males there was a gradual increase from 52% in 2001 to 61% in 2008, and 60% in both 2009 and

2010. Test numbers increased significantly over time in both males (278%) and females (168%), and greatest in those aged 15 to 29 years (males 338%, females 180%) (all P_{trend} <0.001) (Figure 3.3).

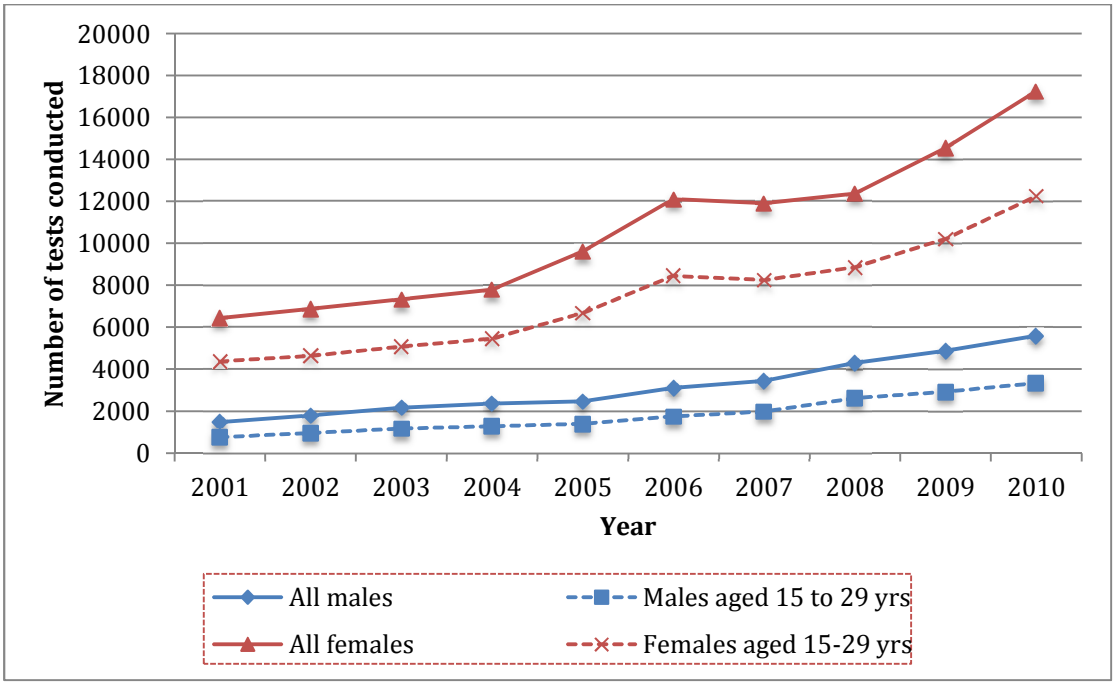

Figure 3.3: Total number of chlamydia tests by year and sex, and number of tests in those aged 15 to 29 years by year and sex, Tasmania, 2001 to 2010

3.3.2.3 Positivity

A total of 10,729 (7.8%) chlamydia tests were positive, 11.2% of male tests (n=3,544) and 6.8% of female tests (n=7,185). The median age of males with positive tests was 23 years (IQR 20-27 years) and in females was 20 years (IQR 18-23 years). Positivity increased in males from 5.8% to 12.4% and in females from 5.4% to 8.1% (both P_{trend}<0.001). The greatest increases in positivity were in males and females in the age groups 15 to 19 years and 20 to 24 years (Table 3.1).

Table 3.1: Chlamydia test positivity, Tasmania 2001 to 2010, by sex, age group, region, and laboratory type

	Proportion of tests positive									
	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Males										
15-19 years*	8.0	14.0	12.7	12.8	14.4	19.2	19.4	20.7	19.9	20.7
20-24 years*	9.0	15.1	19.0	15.0	21.9	19.3	18.8	19.8	17.8	18.7
25-29 years	6.0	9.9	10.5	13.4	13.7	10.8	13.0	13.1	8.9	12.6
30-34 years	2.0	11.3	7.7	7.8	9.6	8.5	6.6	8.0	7.8	7.7
35-39 years	1.4	5.1	4.9	8.2	8.6	4.1	2.3	5.0	6.1	6.8
40+ years	2.6	1.7	3.3	2.3	2.2	2.5	2.7	3.6	1.3	3.2
Females										
15-19 years*	8.0	10.1	9.8	10.6	12.7	10.7	12.8	14.1	13.1	15.5
20-24 years*	5.3	8.0	8.5	9.2	8.4	8.8	8.4	9.5	7.9	9.7
25-29 years	4.9	3.4	3.7	4.2	4.7	4.8	5.6	3.6	5.0	5.0
30-34 years	3.3	2.3	2.2	1.4	3.4	2.3	2.8	2.5	2.4	3.4
35-39 years	3.8	1.5	0.9	0.8	1.9	3.3	0.2	1.8	1.4	2.3
40+ years	0.6	0.7	1.0	1.1	0.6	1.0	0.9	1.3	0.8	1.1
REGION										
South*	7.6	6.8	6.8	6.8	7.1	7.0	7.4	8.6	7.6	8.9
North*	3.6	6.0	7.3	7.6	8.2	7.2	6.9	8.5	7.4	8.8
North-west*	4.1	6.3	7.1	7.9	9.0	9.5	9.7	9.8	9.2	10.7
Laboratory										
Private*	5.9	6.6	7.3	7.5	8.0	7.7	8.1	9.0	8.2	9.6
Public*	4.6	5.7	6.1	6.3	7.7	6.9	6.6	8.4	6.9	8.1

Note: 10-14 years removed from table due to small numbers, * $P_{trend}<0.001$

3.3.2.4 Regions

When compared to the proportion of the Tasmanian population residing in each region, notifications and testing proportions were higher in the south and north than in the north-west (Table 3.2). Positivity was highest in the north-west (Table 3.1).

Table 3.2: Proportion of Tasmanian population, chlamydia notifications and chlamydia testing, by region

Region	% of Tasmanian population	% of notifications	% of testing
South	50	51	52
North	28	29	31
North-west	22	20	17

3.3.2.5 Laboratories

Private laboratories conducted 72% of the testing (yearly range 67% to 76%). Test positivity was higher in private laboratories, and increased significantly in both private and public laboratories (Table 3.1).

3.3.3 Discussion

Analysis of trends in positivity improved our interpretation of trends in the notification data. Our study was the first in Australia to measure chlamydia positivity at a population level over a 10-year period and compare the results to notifications. We found a significant increase in chlamydia infections in males and females aged between 15 and 24 years, and to a lesser extent in males and females aged 25 to 29 years. These increases remained after allowing for testing effort, inferring the prevalence of chlamydia has increased. Increases in

positivity were found in all regions of Tasmania. Higher positivity and lower testing rates were found in the northwest region, possibly as a result of reduced access to testing. Lower chlamydia testing rates (24) and higher chlamydia positivity (5, 14) have been observed in regional and rural areas in Australia, and access to chlamydia testing has been found to favour more advantaged areas (25). Young people are noted as a priority population, and barriers to accessing sexual health services for young rural people is a focus, of the NSTIS (4)

Our results are supported by the findings of sentinel surveillance. The ACCESS group found a significant increase in positivity in both males and females aged 15 to 29 years from 2006 to 2010, and in multivariate analysis found younger age to be independently correlated with positivity (males 15-19 years, adjusted odds ratio (AOR) 1.22; males 20-24 years AOR 1.32; females 15-19 years AOR 1.71; females 20-24 years AOR 1.58) (5). The Victorian Primary Care Network for Sentinel Surveillance found an increase in chlamydia positivity in both males and females, significant in females and highest in women aged 16 to 19 years (18). Targeted Australian studies have also found increases in chlamydia positivity over time, after adjusting for changes in clinical presentation, sexual behavior and demographics in both men (16) and women (17).

Large increases in testing were observed over the 10 years, with the greatest increases in males, particularly young males, indicating the gender gap in testing practices is narrowing. We were unable to adjust our testing for variations in the population being screened, such as symptom status or sexual exposure and therefore could not determine any changes in the characteristics of the males being tested.

General practitioners (GPs) play a crucial role in the identification of chlamydia infection in the Australian population regardless of age, sex or geographic location of the patient (26). GPs notified the majority of cases in our study, and it is likely that the large increase in testing observed in our study was primarily a result of an increase in testing by GPs. We were unable to analyse our testing data by healthcare provider; however, as our analysis of testing data found that most of the testing was conducted in private laboratories, and as our notification data showed that GPs made up a large proportion of users of the private laboratory system, we believe the notification data can be extrapolated to the testing data. We acknowledge the contribution GPs are making to the testing of young people for chlamydia, and recommend that GPs continue to work towards achieving optimal testing rates by addressing barriers to testing such as time pressures, lack of knowledge (27), and concerns about discussing sexual health (20). We reiterate the priority of the NSTIS to increase support of GP screening initiatives (4), and recommend provision of funding to assist GPs to screen patients more comprehensively (26).

The number of notified cases and the number of positive tests were very similar, with 7% more positive tests reported over the 10 years than notified cases. The difference might be explained by inclusion of repeat tests or ocular infections in the testing data, or under-reporting in the notification data. This limitation was consistent across all years of the study and should not have an effect on the observed trends, strengthening our assertion that the trends observed in the testing data can be extrapolated to the notified cases.

Ongoing data collection and reporting of population-level positivity could be improved by the inclusion of both a unique identifier for patients and the type of healthcare provider ordering the test.

A range of commercial nucleic acid tests with minor variations in lower limits of detection, were used in laboratories throughout the period of the study. This may have had a small influence on the positivity rate. Exclusion of second, post treatment, specimens collected within the same month is likely to reduce the impact of variation in detection rates. Similarly local and temporal changes in specimen type may also have impacted the detection rates (L. Cooley, Head of Microbiology, Royal Hobart Hospital, Tasmania, personal communication, 2014).

The greatest strength of our study was its coverage of the whole population tested for chlamydia in Tasmania. Lewis et al (2012) (15) point out in their comprehensive review that as chlamydia testing rates continue to increase in Australia, surveillance data will be able to provide a more reliable estimate of the prevalence of chlamydia in the population. In the meantime, costs of ongoing studies to monitor chlamydia prevalence at a population level are prohibitive, and sentinel surveillance is only able to provide data on targeted populations (5, 18). Surveillance data, generally, is limited by low testing rates, asymptomatic infection, and other characteristics that prevent people from either presenting to health practitioners to be tested for infection, or by health practitioners choosing not to test. Despite this, we have demonstrated that analysis of laboratory testing data is useful for surveillance purposes, to allow for general adjustment of testing practices and, importantly, to enable reporting of trends for public health purposes. Monitoring trends in population-level positivity is sustainable and

cost-effective, and could be included routinely in public health surveillance and reporting. We were able to add a considerable amount of epidemiological knowledge by measuring chlamydia positivity trends at a whole-state level.

Reporting on positivity is an improved method of chlamydia surveillance and we recommend that health departments seek population-level chlamydia testing data as a surveillance tool, whenever possible. This will enable health authorities to enhance their surveillance reports, which will in turn improve the ability of policy makers and public health practitioners to develop, monitor and evaluate chlamydia prevention and control activities. It will also directly address one of the key priorities of the NSTIS, being: to improve methods of measuring testing coverage for STIs (4).

3.3.3.1 ***Postscript***

This chapter measured chlamydia test positivity at a population level, based on all tests conducted in the population. Tests were deidentified. Chapters 5, 6 and 7 examine population-level testing based on individuals, and assess the impact of geographic location and socio-economic status on the testing and positivity trends.

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3.4 Attachment for Chapter 3 — Improving public health surveillance of chlamydia: analysis of population-level positivity trends

Stephens N, Coleman D, Shaw K, O'Sullivan M, Venn A. Improving public health surveillance of chlamydia: analysis of population-level positivity trends. *Sexual Health* 2015; 12(4): 369-371.

Chapter 4

Exploration of testing practices and population characteristics support an increase in chlamydia positivity in Tasmania between 2001 and 2010

Stephens N, Coleman D, Shaw K, O'Sullivan M, Vally H, Venn A. Exploration of testing practices and population characteristics support an increase in chlamydia positivity in Tasmania between 2001 and 2010. *Aust NZ J Public Health* 2015; doi: 10.1111/1753-6405. 12502 [Epub ahead of print].

Chapter 4 — Exploration of testing practices and population characteristics support an increase in chlamydia positivity in Tasmania between 2001 and 2010

4.1 Preface

In the previous chapter, we compared chlamydia notification data with laboratory testing data and demonstrated that after allowing for testing effort an increase in chlamydia infections in young people was observed.

In this chapter, we explore whether the symptom status, reason for testing, or sexual exposure of notified cases could explain the observed positivity trends.

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4.2 Abstract

4.2.1 Objective

The proportion of positive chlamydia tests in young people in Tasmania increased significantly between 2001 and 2010. Whilst female positivity rates increased steadily, male positivity rose steeply to 2005 then stabilised. Crude positivity rates can be influenced by a variety of factors making interpretation difficult. Unique Tasmanian datasets were used to explore whether symptom status, reason for testing or sexual exposure could explain the observed positivity trends.

4.2.2 Methods

Population-level chlamydia positivity rates in Tasmania over a ten-year period were compared with surveillance data collected on people aged 15 to 29 years notified with chlamydia.

4.2.3 Results

The proportion of asymptomatic chlamydia cases increased, with the largest increase in males aged 15 to 19 years (28%). Opportunistic testing of cases increased (greatest in males, range 17-32%). Sexual exposure remained consistent.

4.2.4 Conclusions

After allowing for any changes in sexual exposure, symptom status, and reason for testing, an increase in chlamydia positivity occurred over the 10 years. Healthcare providers have increased chlamydia testing in high risk groups.

4.2.5 Implications

Monitoring chlamydia testing patterns and positivity rates at a population level is a major step forward in surveillance practices. Targeted surveys provide valuable information to supplement routine surveillance data.

4.3 Introduction

Chlamydia trachomatis (chlamydia) is Australia's most frequently notified communicable disease (1). Young people are disproportionately affected, with over 80 per cent of notifications occurring in males and females aged less than 30 years (1, 2). Untreated infections are associated with an increased risk of pelvic inflammatory disease, ectopic pregnancy and infertility (3, 4), and the morbidity associated with chlamydia impacts significantly on health service costs (5-7).

Effective diagnosis and treatment of people infected with chlamydia is the key to controlling the spread of infection (8). Targeted testing of priority populations is essential. Under the Australian Government's Third National Sexually Transmissible Infections Strategy (National STI Strategy), sexually active young people aged under 30 years are an important priority population due to their high notification rates (2). Mathematical modelling indicates that adequate levels of testing for chlamydia infection can result in a significant reduction in prevalence (8, 9). Specifically, Regan et al (2008) found that if 40% of people aged less than 25 years in Australia were tested annually, chlamydia prevalence would reduce dramatically over a 10 year period, with over 50% of the reduction occurring within the first four years (8). Similar optimal testing coverage rates have been suggested in modelling studies conducted in the Netherlands, where it was reported that a 30% testing coverage would have a substantial impact (9).

The National STI Strategy (2) stresses the importance of ongoing support and training of healthcare providers to address any issues and barriers to testing of at risk populations; including how to raise an STI-testing opportunity in a non-

sexual-health consultation. It has been reported that as many as three quarters of chlamydia cases can be missed if STI-testing is limited to only those who display genital symptoms or report a partner with an STI (10). As chlamydia is mostly asymptomatic (3, 11, 12), regular testing of all sexually active young people, not just those who present with symptoms, is a vital component of strategies to increase testing efforts (2). General practitioners (GPs) are the main providers of sexual health services in Australia and play a crucial role in the identification of chlamydia infection in the population regardless of age, sex or geographic location of the patient (2, 13-15). However, a survey of GPs (16) and results from the Australian Collaboration for Chlamydia Enhanced Sentinel Surveillance (17), show that GPs are more likely to test patients who report symptoms of chlamydia or a recent risk event (contact tracing).

Notification rates can reflect testing practices (18) and caution is needed when interpreting chlamydia notification trends without knowledge of the tested denominator (19). To help overcome this limitation, we previously reviewed all chlamydia tests conducted in Tasmania from 2001 to 2010 (20). Tasmania is an island state of Australia with a population of about 510,000. People aged 15 to 29 years accounted for around 19% of the population across all years of our study. Our analysis found a significant increase in both testing rates and the proportion of positive chlamydia tests (chlamydia positivity). The largest increases in testing were in males aged 15 to 19 years, in whom testing increased 475% over the 10 years, followed by males aged 20 to 24 years and males aged 25 to 29 years. The greatest increases in positivity were in males and females in the age groups 15 to 19 years and 20 to 24 years, and males aged 25

to 29 years. We found that chlamydia positivity in young males rose steeply from 2001 to 2005, after which time it stabilised to 2010. Female chlamydia positivity rose more steadily from 2001 to 2010 (20).

Characteristics of the tested population and risk behaviours can impact on crude positivity rates (21) and in this paper we assess these influences on the observed chlamydia positivity trends in Tasmania. For the first time in Australia we were able to perform these analyses at a population level, focusing on symptom status, reason for testing, and sexual exposure of people aged 15 to 29 years notified with chlamydia from 2001 to 2010 and comparing the results with the positivity trends.

4.3.1 Methods

4.3.1.1 Data sources and study population

Our study population included all people aged 15 to 29 years living in Tasmania between 2001 and 2010 with a laboratory confirmed *Chlamydia trachomatis* (chlamydia) infection (22) notified to the Department of Health and Human Services (DHHS), Tasmania. People with a laboratory confirmed positive test with a collection date within the previous four weeks were excluded as part of routine surveillance practices. Laboratories are required under the *Public Health Act Tasmania 1997* to notify all laboratory-confirmed cases of chlamydia to the DHHS (23). Data collected from mandated laboratory notifications include the specimen collection date, first two letters of the case's given name and first two letters of the case's surname (name coded), date of birth, sex and postcode of residence (24). Additional data on sexual exposure, symptom status and reason

for testing were collected from the diagnosing clinician of each case by a standard one-page mailed questionnaire (14). Clinicians were asked: 1/ whether the case reported sexual exposure with person(s) of the opposite sex only; person(s) of the same sex only; person(s) of both sexes; or unknown sexual exposure; 2/ whether the case was symptomatic or asymptomatic; and 3/ if asymptomatic, whether the case was tested opportunistically or as a result of contact tracing.

Extensive discussions were held with all pathology laboratories in Tasmania to highlight the importance of collecting denominator data in order to improve interpretation of the chlamydia notification trends. It was agreed that laboratory data would be combined by the researchers, and that the testing conducted by individual laboratories would not be reported. Laboratories provided the age, sex, postcode of residence and result of test for all chlamydia tests generated by Tasmanian-based clinicians from 2001 to 2010. No identifying information was collected.

4.3.1.2 Statistical Analyses

Case notifications were analysed by year, age group (15-19 years, 20-24 years, 25-29 years), sex, sexual exposure, symptom status and reason for testing. Testing data were analysed by year, result of test, age group and sex. Positivity was calculated by dividing the total number of positive tests by the total number of tests conducted. The overall crude testing rate was calculated by dividing the total number of tests conducted in males and females aged 15 to 29 years, by the total population in that age group in Tasmania over the 10-year study period. Annual crude testing rates were calculated by dividing the number of tests

conducted in males and females by the total male and female populations, separately, by year and age group. Population denominators were derived from the estimated resident population obtained from the Australian Bureau of Statistics (25). All data were extracted into Microsoft Excel spreadsheets and analysed using Stata version 13.1 (Stata Corporation, College Station, TX, US) (Stata). We conducted chi-squared tests to analyse testing and positivity trends, and linear regression to analyse notification trends.

4.3.1.3 Ethics

This research was undertaken in accordance with Tasmania's Personal Information Protection Act 2004 (26), in particular Schedule 1 of the Personal Information Protection Principles contained within the Act. In addition, the release of the dataset was authorised by the Director of Public Health under the provisions of the *Public Health Act 1997* (23). De-identified data fields relevant to this analysis were extracted from the DHHS database by author 2 for the purposes of this analysis (24).

4.3.2 Results

4.3.2.1 Notifications

There were 8,828 chlamydia infections notified by laboratories in people aged 15 to 29 years over the 10-year study period. Females accounted for 68% (n=6,004) and males 32% (n=2,824). Additional surveillance data was collected for >85% (n=7,536) of cases. The age and sex distributions of cases with additional surveillance data were consistent with the age and sex distributions of all notified cases.

Notification rates increased significantly between 2001 and 2010 in both males and females (both P_{trend}<0.01). In 2010, notification rates were highest in females aged 15 to 19 years (3,698 per 100,000), followed by females aged 20 to 24 years (2,815 per 100,000), males aged 20 to 24 years (1,638 per 100,000), males aged 15 to 19 years (1,096 per 100,000), females aged 25 to 29 years (917 per 100,000) and males aged 25 to 29 (750 per 100,000).

4.3.2.2 Sexual exposure

Data on sexual exposure was reported in 88% (n=1,916) of male and 87% (n=4,122) of female notified cases between 2003 and 2010. The pattern of reported sexual exposure was consistent over the study period in both males and females. Ninety four percent of males (n=1,801) and 96% of females (n=3,957) reported sexual exposure with opposite sex only. More males than females reported same sex exposure (9% of 25-29 year old males vs 4% of 25-29 year old females; 5% 20-24 year old males vs 3% 20-24 year old females; 4% 15-19 year old males vs 3% 15-19 year old females).

4.3.2.3 Symptom status of notified cases

Data on symptom status was collected from 2001 to 2010, and was reported for 85% of males (n=2,389) and 86% of females (n=5,147) notified with chlamydia. Fifty-six percent (n=1,330) of males and 65% (n=3,370) of females were asymptomatic when tested. The proportion of males who were asymptomatic when tested increased by 15% between 2001 and 2010. The steepest increase was in males aged 15 to 19 years (28%). The proportion of females who were asymptomatic when tested increased by 6% (Table 4.1). In males, there was a sustained crossover in 2005 in the symptom status proportions (Figure 4.1). In

females, the asymptomatic proportion remained consistently higher than the symptomatic proportion each year with the exception of one year (Figure 2). Forty four percent of male cases (n=1,059) and 35% of female cases (n=1,777) were tested after presenting to their treating clinician with symptoms (Table 4.1).

Table 4.1: Notified chlamydia cases by symptom status, and reason for testing asymptomatic cases; and, total number of chlamydia tests conducted and test positivity rates, by age group and sex, Tasmania 2001 to 2010

		Proportions (%)									
		2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Symptom status – all notified cases											
Males											
15-19yrs	Symptomatic	65	59	43	54	39	49	32	38	39	37
	Asymptomatic	35	41	57	56	61	51	68	62	61	63
20-24yrs	Symptomatic	50	57	57	58	50	42	42	44	42	40
	Asymptomatic	50	43	43	42	50	58	58	56	58	60
25-29yrs	Symptomatic	58	67	63	61	50	47	41	34	42	50
	Asymptomatic	42	33	37	39	50	53	59	66	58	50
Females											
15-19yrs	Symptomatic	43	48	35	39	42	36	37	30	35	34
	Asymptomatic	57	52	65	61	58	64	63	70	65	66
20-24yrs	Symptomatic	39	51	33	36	36	30	30	29	31	32
	Asymptomatic	61	49	67	64	64	70	70	71	69	68
25-29yrs	Symptomatic	33	61	34	43	31	36	34	24	37	31
	Asymptomatic	67	39	66	57	69	64	66	76	69	69
Reason for testing - asymptomatic notified cases											
Males											
15-19yrs	Contact tracing	86	78	69	92	79	83	60	48	52	63
	Opportunistic	14	22	31	8	21	17	40	53	48	37
20-24yrs	Contact tracing	71	68	74	73	82	74	62	56	51	54
	Opportunistic	29	32	26	27	18	26	38	44	49	46
25-29yrs	Contact tracing	75	78	69	73	61	63	54	49	51	43
	Opportunistic	25	22	31	27	39	38	46	51	49	57
Females											

		Proportions (%)									
		2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
15-19yrs	Contact tracing	28	21	26	25	14	15	17	21	26	16
	Opportunistic	72	79	74	75	86	85	83	79	74	84
20-24yrs	Contact tracing	20	21	17	16	21	14	29	24	19	19
	Opportunistic	80	79	83	84	79	86	71	76	81	81
25-29yrs	Contact tracing	31	56	20	21	30	24	15	19	38	16
	Opportunistic	69	44	80	79	70	76	85	81	63	84
Number of tests conducted and positivity (proportion of tests positive)											
Males											
15-19yrs	No. of tests	159	179	228	273	299	375	463	647	759	914
	Positivity	8	14	13	13	14	19	19	21	20	21
20-24yrs	No. of tests	351	444	542	618	635	800	896	1152	1311	1453
	Positivity	9	15	19	15	22	19	19	20	18	19
25-29yrs	No. of tests	251	333	389	382	454	557	610	807	821	939
	Positivity	6	10	11	13	14	11	13	13	9	13
Females											
15-19yrs	No. of tests	1397	1441	1729	1825	2119	2709	2626	2931	3322	4188
	Positivity	8	10	10	11	13	11	13	14	13	15
20-24yrs	No. of tests	1863	2068	2169	2293	2934	3703	3468	3682	4197	5001
	Positivity	5	8	8	9	8	9	8	9	8	10
25-29yrs	No. of tests	1071	1096	1132	1282	1556	1967	2052	2115	2517	2894
	Positivity	5	3	4	4	5	5	6	4	5	5

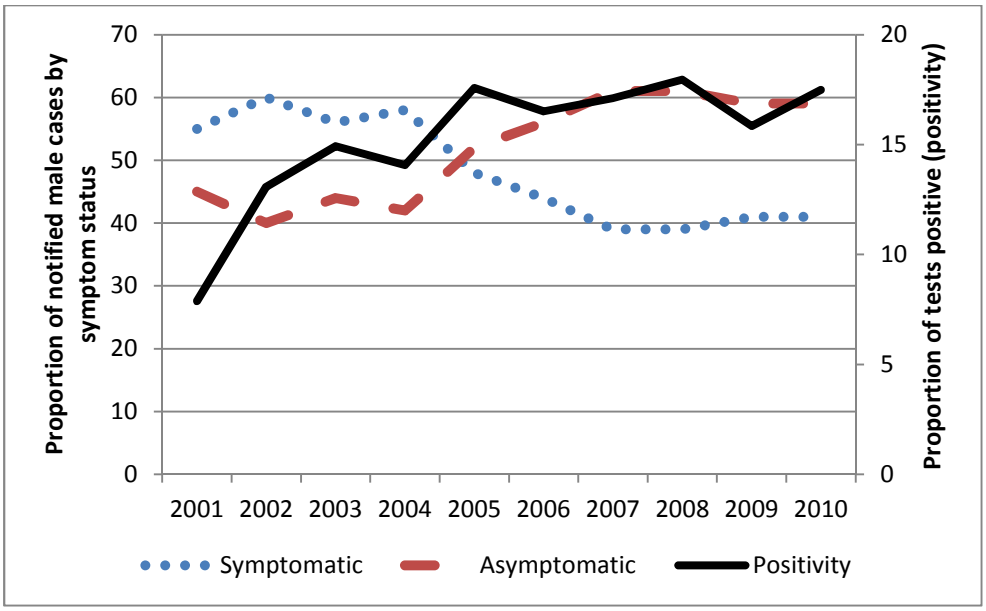

Figure 4.1: Symptom status at time of testing notified cases of chlamydia, and proportion of all chlamydia tests conducted that were positive, in males aged 15 to 29 years, Tasmania from 2001 to 2010

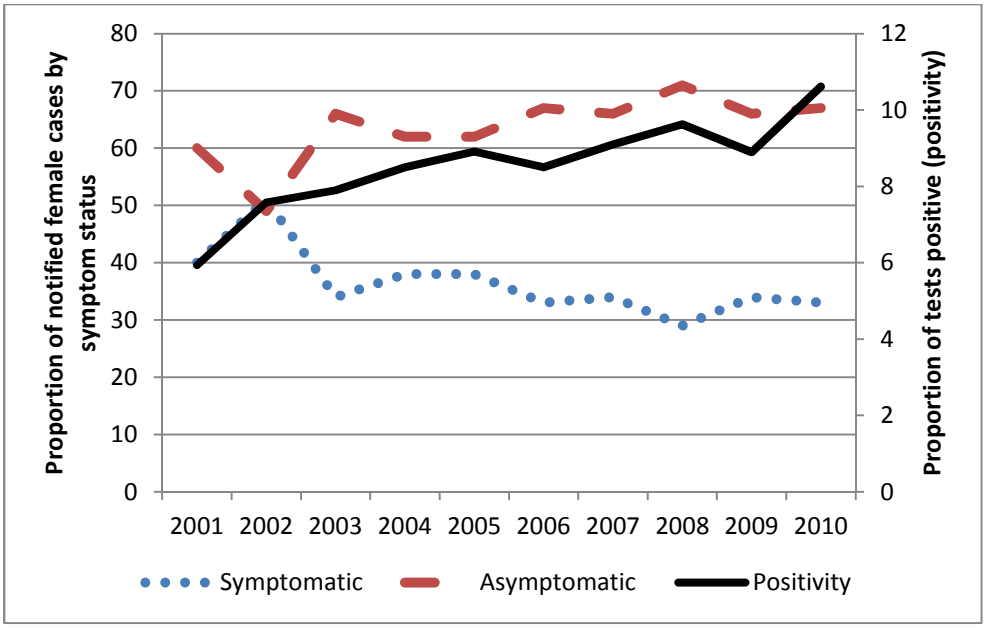

Figure 4.2: Symptom status at time of testing notified cases of chlamydia, and proportion of all chlamydia tests conducted that were positive, in females aged 15 to 29 years, Tasmania, from 2001 to 2010

4.3.2.4 Reason for testing – asymptomatic cases

Data on reason for testing was collected from 2001 to 2010, in 85% of males (n=2,389) and 86% of females (n=5,147) notified with chlamydia. Of the 1,330 asymptomatic male cases, 61% (n=805) were tested as a result of contact tracing, with the remaining 39% (n=525) tested opportunistically. The proportion tested opportunistically increased over time. The largest increases were observed in males aged 25 to 29 years in whom opportunistic tests increased by 32% from 2001 to 2010, followed by males aged 15 to 19 years (23% increase), and males aged 20 to 24 years (17% increase). Of the 3,370 asymptomatic female cases, 21% (n=692) were tested as a result of contact tracing and 79% (n=2,678) were tested opportunistically. Smaller increases in the proportion of female cases tested opportunistically were observed, with the largest increase seen in the oldest age group (13% in 15-19 years; 1% in 20-24 years; 15% in 25-29 years) (Table 4.1).

4.3.2.5 Testing and positivity

There were 91,972 chlamydia tests conducted in people aged 15 to 29 years from 2001 to 2010, equating to an overall crude testing rate of 10%. Crude annual testing rates increased from 2% to 7% in males and from 10% to 26% in females, from 2001 to 2010. Tests with indeterminate results (0.5%) and in whom sex was not reported (0.2%) were excluded, leaving 91,388 tests in our analysis. Twenty percent (n=18,041) of tests were in males and 80% (n=73,347) were in females. Sixteen per cent (n=2,908) of male tests and 9% (n=6,519) of female tests were positive for chlamydia. The median age of males tested was 22

years and of females tested was 21 years. Of those with a positive result, the median age of males was 21 years and median age of females was 20 years.

In all males, positivity increased from 8% in 2001 to 17% in 2010 (Figure 4.1). Positivity in males aged 15 to 19 years increased steeply from 8% in 2001 to 19% in 2006, at which time it stabilised, fluctuating between 19% and 21% from 2006 to 2010 ($p<0.001$). In males aged 20 to 24 years, positivity increased from 9% in 2001 to a peak of 22% in 2005, before stabilising with a range of 18% to 20% from 2006 to 2010 ($p<0.001$). Positivity in males aged 25 to 29 years increased from 6% in 2001 to a peak of 14% in 2005, and fluctuated to 2010 ($p=0.01$). In all females, positivity increased from 6% in 2001 to 11% in 2010 (Figure 4.2). In females aged 15 to 24 years, increases in positivity were less steep than males and more consistent over the 10 years. In females aged 15 to 19 years, positivity increased from 8% in 2001 to 15% in 2010 ($p<0.001$), and in 20 to 24 year old females, positivity increased from 5% in 2001 to 10% in 2010 ($p<0.001$). The positivity rate fluctuated in females aged 25 to 29 years with a smaller increase over the 10 years, 4.9% to 5.0% ($p=0.04$) (Table 4.1).

4.3.3 Discussion

Adequate levels of testing for chlamydia in sexually active young people, both symptomatic and asymptomatic, is a key public health goal, fundamental to the success of strategies to control the chlamydia epidemic in Australia (2, 27). Despite recent increases in the rate of chlamydia testing in some populations, further improvements in testing of people from at risk groups and methods to monitor testing coverage, are critical (2, 28).

Current Australian health department surveillance, and sentinel targeted surveillance activities, are unable to monitor population-level testing practices, nor determine the characteristics of the whole population being tested. For the first time in Australia, we are able to report 10-year chlamydia positivity trends, and assess the symptom status, reason for testing, and sexual exposure of people being tested for chlamydia, at a population level. Pleasing increases in chlamydia testing in Tasmania in young people generally (20), and, importantly, increased testing of asymptomatic young people aged 15 to 29 years were found. This suggests that healthcare providers (HCPs) are striving to reach the goals set by the National STI Strategy (2).

Males have consistently been underrepresented in chlamydia notification data, despite the infection being equally transmitted in males and females (29), and asymptomatic males are also less likely than asymptomatic females to be tested for chlamydia (30). Yeung et al (2014) found that both males and females are likely to agree to chlamydia testing if asked, regardless of symptom status (10). In our study, although females still made up the greatest proportion of notified cases, we found that HCPs increased their testing in males at a greater rate than in females (20), and, most notably, their testing of asymptomatic young males.

Males aged between 15 and 29 years generally access healthcare infrequently and do not routinely consult a doctor about their sexual health (31) unless symptomatic or alerted through partner notification systems (contact tracing) (14). In this study, we found increases in testing for chlamydia infection that occurred opportunistically. These increases were again most notable in males. In the earlier years of our study, the proportion of asymptomatic young males

who were tested as a result of contact tracing was dominant; however that proportion changed over time, with the gap narrowing between those tested as a result of contact tracing and those tested opportunistically.

We also explored the influence of sexual exposure on positivity trends. Gay men and other men who have sex with men have a higher prevalence of STIs (2, 32) and an increase in testing in this population could impact trends in positivity. Our results show that sexual exposure remained consistent over the study period.

In our interpretation of the data we have assumed that the pattern of testing observed in the notified cases (people who tested positive and were notified to the DHHS) is the same in people who tested negative for chlamydia. We therefore assume that the proportion of asymptomatic people who were tested but were negative for chlamydia has increased at a similar rate to those who tested positive. In other words, we conclude that HCPs are testing more asymptomatic young people, generally.

Following this hypothesis, the pattern of symptom status in notified cases over the 10 years of our study can help explain the observed positivity trends. The flattening of the positivity rate in males from 2005 through to 2010 occurred simultaneously with increases in the proportion of asymptomatic male cases notified to the DHHS. We postulate that an increase in testing of asymptomatic young males overall (that is, a change in the population being tested) contributed to the flattening of the positivity rate, and that the flattening rate does not reflect a decrease in the prevalence of cases in the young male population.

Similar findings have been described by Vodstrcil et al (2011), who in their retrospective review of data held by the Melbourne Sexual Health Centre, found that chlamydia positivity in men who have sex with men (MSM) did not change significantly between 2002 and 2009, while at the same time the proportion of those presenting with symptoms decreased ($p<0.01$). They argued that the flattening of the positivity rate in the MSM resulted from the high testing rates in that population (about half of MSM reported being tested each year) and the decrease in symptomatic presentation (33).

The additional surveillance data we collected from clinicians as part of our study provided us with valuable information on the characteristics of notified cases. Good response rates were obtained for collection of data on all three characteristics of interest allowing us to better understand the trends in the passive routine surveillance data. We found no demographic differences between the cases for whom we collected additional surveillance data and for whom we did not, suggesting the risk of selection bias was minimised. However, as the additional surveillance data was collected from diagnosing clinicians rather than the notified cases themselves, the data was dependent on the accuracy of the clinicians' responses.

The greatest strength of our study was that it was based on the whole population in Tasmania. There were several limitations. We found that only 10% of the population in the study age group had been tested, equivalent to that reported previously in young Australian adults (10, 17). This limitation may have decreased over the time of our study, as the number of tests conducted in young people increased, and as the proportion of asymptomatic people tested

increased. The surveillance practice of excluding cases notified within 30 days of a previous positive result may have resulted in some testing data being included without a matching notified case. Male testing rates and notifications were substantially lower than in females, and may have introduced biases to our analyses of both positivity trends and population characteristics. Studies have demonstrated that the prevalence of chlamydia is similar in males and females (30); therefore, the higher positivity rate we found in males is likely to be a reflection of the lower testing rates and the higher proportion of symptomatic males tested (34), rather than higher male prevalence. Further, our data is Tasmania-specific, and the generalisability of our findings to other geographical areas is unknown.

The gold standard for reporting population level positivity would be to report on persons tested rather than tests conducted. Our study was limited by the de-identified nature of both the laboratory and notification data. We were unable to ascertain whether a person was tested or notified more than once in each year. Repeat tests can inflate estimates of population testing coverage based on the number of tests (35), and surveillance data collected on notified cases could be biased by the inclusion of individuals more than once in any year. Collecting unique identifiers and linking the laboratory testing data to allow for analysis of the data by persons would result in a considerable improvement. Under these circumstances, we could measure the proportion of 15-29 year olds receiving a chlamydia test annually, and the proportion that yield a positive result. Collection of individual identifiers would also allow for more sophisticated analyses. Our study was able to demonstrate trends in notification and

laboratory testing data through descriptive analytical techniques. Future research based on individuals, rather than tests, would benefit from the use of multivariable regression analysis to explore the impact age, reason for testing, gender and symptom presentation have on chlamydia positivity.

We conclude that after allowing for any changes in sexual exposure, symptom status, and reason for testing, an increase in chlamydia positivity occurred between 2001 and 2010 in males and females aged 15 to 29 years in Tasmania. Previous studies have suggested that positivity can be used as a proxy measure for prevalence (36, 37) in all healthcare settings, including general practice (36). We were unable to adjust for repeat tests, therefore our denominators may have been overestimated, resulting in an underestimation of prevalence (36, 37); and the lower testing rates in males may have further impacted on the estimation of chlamydia prevalence in males (36, 38). Our results support the findings of others who have reported that the true prevalence of chlamydia is increasing in young people (33, 39).

4.3.4 Implications

We have demonstrated that it is possible to work closely with laboratories to establish a surveillance system that is able to monitor testing practices and chlamydia positivity at a population level. Reporting trends in chlamydia positivity is a more useful method of surveillance than reporting trends in notified cases. In the absence of data being available on individuals tested, health authorities responsible for chlamydia surveillance should strive to report

on crude chlamydia positivity at a population level, thereby providing critical evidence to inform best public health practice and policy that takes into account the influence of testing practices. The collection of sex, date of birth, postcode and result of test for all chlamydia testing conducted in each jurisdiction is achievable and would be a major step forward in chlamydia surveillance in Australia.

We have also shown the value of collecting additional surveillance data from diagnosing clinicians and the possibility of a high response rate. Our data assists in filling an identified gap in knowledge of characteristics of notified cases of chlamydia at a population level (28, 31) and compliments the passive surveillance data collected by health authorities in Australia (21). Collection of additional surveillance data at a population level can be resource intensive particularly for jurisdictions with large populations, but we argue that it is possible to tightly target data collection to key questions and obtain data that is crucial to both public health policy development and to increased understanding of positivity trends. We recommend health authorities conduct periodic surveys of healthcare providers who are diagnosing and treating young patients with chlamydia, and that the surveys are kept to a maximum of five key questions including the symptom status and reason for testing their patients.

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Chapter 5

Testing for chlamydial infection: are we meeting clinical guidelines? Evidence from a state-level data linkage analysis for 15-29 year-olds.

Stephens N, Coleman D, Shaw K, O'Sullivan M, Cooley L, McGregor A, Vally H, Venn A. Testing for chlamydial infection: are we meeting clinical guidelines? Evidence from a state-level data linkage analysis for 15-29 year-olds. Submitted to *Medical Journal of Australia* and is currently under review.

Chapter 5 — Testing for chlamydial infection: are we meeting clinical guidelines? Evidence from a state-level data linkage analysis for 15-29 year-olds

5.1 Preface

Clinical guidelines recommend annual *Chlamydia trachomatis* (chlamydia) tests for all sexually active people aged 15 to 29 years. In this chapter, we report on our linkage of all chlamydia tests conducted in Tasmania in 2012 and 2013 in residents aged 15 to 29 years, to measure adherence to these guidelines and to compare testing rates to the projected levels required to reduce chlamydia prevalence.

This paper has been submitted for publication to the *Medical Journal of Australia* and is currently under review.

5.2 Abstract

5.2.1 Objective

Clinical guidelines recommend annual *Chlamydia trachomatis* (chlamydia) tests for all sexually active people aged 15-29 years. This study measured adherence to these guidelines and compared current testing rates to the projected levels required to reduce chlamydia prevalence.

5.2.2 Design, setting and participants

We linked all chlamydia tests conducted in Tasmania during 2012-2013, in residents aged 15-29 years. Data linkage allowed individuals with multiple tests across different healthcare settings to be counted only once each year in testing rate analyses.

5.2.3 Main outcome measures

Rates of testing and test positivity by age, sex, test rebate status and socioeconomic indicators.

5.2.4 Results

There were 31,899 eligible tests in 24,830 individuals. Testing coverage was higher in females (21%, 19,404/92,685) than males (6%, 5,426/98,123), and highest in females 20-24 years (26%, 8,072/30,558). Positivity was higher in males (16%, 862/5,426) than females (10%, 1,854/19,404). Most tests (81%, 25,803/31,899) were rebateable. Positivity was higher in females with non-rebateable tests (12%, 388/3,116 vs rebateable 9%, 1,466/16,285). Less testing (1.8%, 7,284/391,734) and higher positivity (11%, 822/7,284) were found in areas of most disadvantage compared to middle (1.9%, 9,688/510,754; 10%,

983/9,688) and least (2.0%, 1,680/85,894; 8%, 139/1,680) disadvantaged areas.

5.2.5 Conclusions

Chlamydia testing rates are lower than recommended levels. Sustaining the current testing rates in females aged 20-24 years may reduce population prevalence over 10 years. Our study meets key priorities of national strategies for chlamydia control by providing a method of monitoring testing coverage and evidence to evaluate prevention programs. Our methods could be applied in other geographical areas to monitor testing trends and inform targeted testing.

5.3 Introduction

Chlamydia trachomatis (chlamydia) is Australia's most frequently notified communicable disease and young people aged 15 to 29 years account for 80% of cases (1). Chlamydia is of public health significance because of the short- and long-term sequelae associated with untreated infection, including urethritis, acute epididymitis and infertility in males, and cervicitis, urethritis, pelvic inflammatory disease, infertility, chronic pelvic pain and tubal pregnancy in females (2). Reducing the transmission of chlamydia is a priority under Australia's Third National Sexually Transmissible Infections Strategy, and reduction is critically dependent on increasing testing coverage (1). Chlamydia is asymptomatic in up to 80% of infected males and females, which makes it essential that all sexually active young people, not just those presenting with symptoms, be screened to detect the majority of cases and provide treatment (3). Mathematical modelling has demonstrated that large reductions in chlamydia prevalence are possible, provided there is adequate testing coverage in the target population (3). The Royal Australian College of General Practitioners (4) and the Australian STI Management Guidelines (5) recommend annual screening of all sexually active young people aged <30 years.

Under public health legislation in Australia, laboratories (and doctors in some states) are required to report chlamydia diagnoses to their jurisdiction's health department. These reports routinely include the date of specimen collection or diagnosis date, and the diagnosed person's sex, age and postcode of residence (6). This enables national and local analysis of notifications by sex, age and geographic location (7, 8). However, these chlamydia surveillance practices do

not include the collection of data on negative tests (people who were tested for chlamydia but tested negative) (testing data). This limitation can result in bias when planning and evaluating policies and prevention activities as it does not allow for the impact of fluctuating patterns of testing coverage. Chlamydia testing data is also necessary to monitor progress against recommended clinical testing targets (1). Sentinel surveillance and studies in Australia have been able to partially address this knowledge gap by reporting on chlamydia testing coverage in selected populations (9-14), but are limited by the inclusion of restricted samples of laboratory data, treating healthcare practitioners or facilities.

For the first time in Australia, we undertook data linkage of all chlamydia testing conducted by both public and private healthcare providers, in people aged 15-29 years at a state-population level over a two-year period. Our study design enabled us to include every test conducted in the population and to link individuals who may have been tested more than once, by more than one healthcare provider and in more than one laboratory. This linkage enabled us to meet the primary research aims of our study, being: 1/ to assess adherence to clinical guidelines for chlamydia testing; 2/ to identify demographic and clinical setting differences; and 3/ compare the results to strategies to reduce chlamydia prevalence.

5.3.1 Methods

5.3.1.1 Study population and laboratory testing data

People aged 15 to 29 years resident in Tasmania (an island state of Australia of approximately 512,000 people). People in the study age group made up 19% of the state's population in 2012 (n=95,837) and 18% in 2013 (n=94,988) (15). Results of every chlamydia test conducted from 1 January 2012 to 31 December 2013 were collected from all public and private laboratories and made available to the Tasmanian Data Linkage Unit (TDLU) (16).

5.3.1.2 Data linkage

Data linkage was conducted at the TDLU through a process of 'Probabilistic Linkage' which involved linking the datasets using a combination of unique identifiers together with a base level of administrative variables including name, address, date of birth and sex with the requirement that records being compared agree on all characters. Unique patient identifiers were created and a de-identified dataset made available to the authors for the purpose of analysis that included the variables: laboratory identifier, unique patient identifier, postcode of residence, date of birth and sex; date, and result of test; and Medicare rebate (a government payment for conducting a test) eligibility status (coded as rebateable or non-rebateable).

5.3.1.3 Socioeconomic indicators

Each person was assigned an Index of Relative Socioeconomic Disadvantage (IRSD) decile score as prescribed under the 2011 Socio-economic Indexes for Areas (SEIFA), based on their postcode of residence. SEIFA is a product

developed by the Australian Bureau of Statistics that ranks areas in Australia according to their relative socio-economic advantage and disadvantage. The population-based IRSD deciles represent groups of individuals who live in similarly ranked areas. IRSD scores range from 1 to 10, with 1 being the most disadvantaged relative to the other deciles (17). For analysis purposes, IRSD scores were categorised into three groups based on deciles 1 and 2 (most-disadvantaged areas), 3 to 8 (middle-disadvantaged areas) to 9 and 10 (least-disadvantaged areas). Analysis was restricted to people tested at private laboratories. Postcodes of people tested at public laboratories were unreliable due to an unknown proportion allocated the postcode of sexual health services, corrective services and youth centres.

5.3.1.4 Estimates of the sexually active population

Two data sources were utilised for estimating the sexually-active proportion of the population: 1/ the Second Australian Study of Health and Relationships that examined the age of first vaginal sex via a nationally representative sample of 20,094 Australian residents aged 16 to 69 years in 2012 and 2013 (18); and 2/ the 2013 5th National Survey of Australian Secondary Students and Sexual Health which enrolled over 2,000 year 10, 11 and 12 students from across public and private school systems and examined the age at first intercourse (19). We defined sexually active as having ever had any type of sexual intercourse.

5.3.1.5 Analysis

We measured the number of tests conducted, test positivity, test rebate status and disadvantage score by age group (15 to 19; 20 to 24; 25 to 29 years) and sex; and the number of individuals tested and individual positivity, by age and sex.

Each person was counted once in a 12-month period, and repeat tests were removed. In individuals with multiple tests and discrepant results, the positive test was retained.

Population denominators were derived from the estimated resident population of each collection district obtained from the Australian Bureau of Statistics for 2012 and 2013. Chlamydia positivity rates were calculated by dividing the number of positive tests by the number of tests conducted. Equivocal tests (tests unable to be confirmed as positive or negative) were excluded.

In the estimated sexually active population, the numbers of individuals tested were calculated by sex and single age between 15-20 years and by the age group 21-29 years, based on census population denominators and in line with the available sexually active population estimates described above.

Data were analysed using Stata version 14.1 (Stata Corporation, College Station, TX, US). We conducted chi-squared tests to analyse testing and positivity trends and linear regression to assess testing and positivity by IRSD score.

5.3.1.6 Ethical approval

This study was approved by the Tasmanian Health and Medical Human Research Ethics Committee.

5.3.2 Results

5.3.2.1 Study population and laboratory testing data

A total of 32,791 nucleic acid tests were conducted in 24,830 individuals; 74% were conducted in private laboratories; 180 (0.5%) were excluded due to

equivocal or missing results and 712 (2%) due to missing or interstate postcode. Females made up 79% (25,130/31,899) of tests included in the study.

5.3.2.2 Rates of testing and positivity

The highest rate of testing was conducted in females aged 20-24 years. Across all age groups, tests in males were significantly lower than in females ($p<0.001$). The testing rate in males and females combined for the age range 15-29 years was 13%, and in the age range 15-24 years was 14% (Table 1).

Test positivity was highest in males aged less than 20 years (Table 1). Males ($p<0.01$) and females ($p<0.001$) aged 25-29 years were significantly less likely to have a positive test than younger age groups (Table 5.1).

Table 5.1: Population rates of testing and test positivity, in males and females aged 15 to 29 years tested for chlamydial infection in Tasmania in 2012 and 2013

	No. of tests	No. of positive tests	Positivity	No. of individuals tested*	No. of individuals with a positive test**	Individual positivity**	Census population 2012 & 2013	Population testing rate
Males								
15-19 years	1907	412	22%	1531	272	18%	35250	4%
20-24 years	3181	646	20%	2538	431	17%	32754	8%
25-29 years	1681	255	15%	1357	159	12%	30119	5%
Total	6769	1313	19%	5426	862	16%	98123	6%
Females								
15-19 years	8656	1685	20%	6343	874	14%	32357	20%
20-24 years	10523	1482	14%	8072	751	9%	30558	26%
25-29 years	5951	424	7%	4989	229	5%	29770	17%
Total	25130	3591	14%	19404	1854	10%	92685	21%

	No. of tests	No. of positive tests	Positivity	No. of individuals tested*	No. of individuals with a positive test**	Individual positivity**	Census population 2012 & 2013	Population testing rate
Combined - males and females								
15-19 years	10563	2097	20%	7874	1146	15%	67607	12%
20-24 years	13704	2128	16%	10610	1182	11%	63312	17%
25-29 years	7632	679	9%	6346	388	6%	59889	11%
Total	31899	4904	15%	24830	2716	11%	190808	13%
Combined - males and females								
15-24 years	24267	4225	17%	18484	2328	13%	130919	14%

*individuals counted once in a 12 month period, **repeat tests removed, in individuals with discrepant results positive tests retained

5.3.2.3 Sexually active population rates of testing and positivity

The proportion of the population estimated to be sexually active ranged from 14% (15-year-old females) to 96% (21-29 year-old males) (18,19). Under these assumed estimates, the annual testing rate for sexually active people in the age range 15-29 years was 18%, and in the age range 15-24 years was 20% (Table 5.2).

Test positivity amongst the estimated sexually active population was highest in males aged 19 years (Table 5.2).

5.3.2.4 Socioeconomic indicators

Less testing (1.8%, 7,284/391,734) occurred in areas of most disadvantage, compared to testing in middle (1.9%, 9,688/510,754) and least disadvantaged (2.0%, 1,680/85,894) areas (p=0.01). People living in most disadvantaged areas were more likely to have a positive result (11%, 822/7,284) than people living in middle (10%, 983/9,688) and least (8%, 139/1,680) disadvantaged areas (p=0.01) (Table 5.3).

Table 5.2: Proportion of the estimated sexually active[a,b] males and females aged 15 to 29 years tested for chlamydia in Tasmania in 2012 and 2013

	No. of individuals tested*	No. of individuals with a positive test	Individual positivity	Census population 2012 & 2013	Population testing rate	Estimated sexually active proportion of population		Testing rate in sexually active
Males						%	No.	
15 years	89	8	9%	6853	1%	18[a]-22%[b]	1234-1508	6%-7%
16 years	200	29	15%	7021	3%	34[a]-36%[b]	2387-2528	8%
17 years	334	48	14%	7176	5%	52%[a,b]	3732	9%
18 years	439	88	20%	7205	6%	67%[a]	4827	9%
19 years	469	99	21%	6995	7%	75%[a]	5246	9%
20 years	535	102	19%	6768	8%	81%[a]	5482	10%
21-29 years	3360	488	15%	56105	6%	96%[a]	53861	6%
Females								
15 years	540	60	11%	6423	8%	14[a]-23%[b]	899-1477	37%-60%
16 years	890	137	15%	6584	14%	32[a]-34%[b]	2107-2239	40%-42%

	No. of individuals tested*	No. of individuals with a positive test	Individual positivity	Census population 2012 & 2013	Population testing rate	Estimated sexually active proportion of population		Testing rate in sexually active
17 years	1415	182	13%	6622	21%	49%[a,b]	3245	44%
18 years	1717	263	15%	6464	27%	65%[a]	4202	41%
19 years	1781	232	13%	6264	28%	74%[a]	4635	38%
20 years	1700	210	12%	6195	27%	80%[a]	4956	34%
21-29 years	11361	770	7%	54133	21%	95%[a]	51426	22%

[a]calculated from the Second Australian Study of Health and Relationships[21]; [b]calculated from the 5th National Survey of Australian Secondary Students and Sexual Health[22]; *individuals counted once in a 12 month period; **repeat tests removed, and in individuals with discrepant results, positive tests retained

Table 5.3: Chlamydia tests and positivity, by IRSD score^, males and females aged 15 to 29 years tested in private laboratories, Tasmania 2012 and 2013

	Most disadvantaged areas*			Middle disadvantage areas**			Least disadvantaged areas***		
	No. tested	No. positive	Positivity	No. tested	No. positive	Positivity	No. tested	No. positive	Positivity
Males									
15-19 years	498	95	19%	569	109	18%	82	11	13%
20-24 years	624	123	20%	996	186	17%	221	23	10%
25-29 years	431	48	11%	471	72	13%	119	10	8%
Females									
15-19 years	1812	273	15%	2190	257	12%	301	27	9%
20-24 years	2274	201	9%	3110	273	9%	601	49	8%
25-29 years	1645	82	5%	2352	86	4%	356	19	5%
Combined	7284	822	11%	9688	983	10%	1680	139	8%

^IRSD scores range from 1 to 10, with 1 being the most disadvantaged relative to the other deciles. For analysis purposes, IRSD decile scores were divided into three groups, ranging from 1 and 2 (most-disadvantaged areas), 3 to 8 (middle-disadvantaged areas) to 9 and 10 (least-disadvantaged areas). *Population 195867; ** Population 255377; ***Population 4294

5.3.2.5 Test rebate status

Most tests were eligible for a rebate (81%, 25,803/31,899). The likelihood of a test being eligible for a rebate increased as age increased in both males (p<0.001) and females (p<0.001). In males, no difference was found in test positivity between those with rebateable and those with non-rebateable tests. The likelihood of a positive test was higher in females with non-rebateable tests (females aged 15-19 years, non-rebateable 16%, 202/1,266; rebateable 13%, 672/5,077) (p=0.06), (females aged 20-24 years, non-rebateable 11%, 153/1,433; rebateable 9%, 598/6,638) (p<0.001) (females aged 25-29 years, non-rebateable 8%, 33/147; rebateable 4%, 196/4,570) (p<0.01).

5.3.3 Discussion

5.3.3.1 Adherence to clinical guidelines

Despite clinical guidelines recommending annual chlamydia tests for all sexually active people aged 15 to 29 years, we found an annual testing rate of only 13% in this age group. The testing rate was still low (18%) when assuming the estimated sexually active proportion. Our testing rates were, however, higher than those previously reported in young people attending general practice in Australia (<10%) and considerably higher than those reported in Tasmania (2.4%) in 2007-2008 (10), reflecting an increase in testing rates over the last decade (20).

5.3.3.2 Demographic and clinical differences

Less testing occurred in areas of most disadvantage, but people living in areas of most disadvantage were more likely to have a chlamydia infection diagnosed.

Disadvantage has been similarly reported in New South Wales, where increasing socioeconomic disadvantage was associated with an increased notification risk (11), and in Victoria, where disadvantaged members of the community received significantly less chlamydia testing but had a greater likelihood of testing positive (12). Lack of access to services has previously been cited as leading to less testing in areas of most disadvantage (12, 21); and people living in areas of most disadvantage are also less likely to submit a specimen and to be tested for chlamydial infection when requested by a general practitioner (GP) (21).

The large majority of tests in our study were rebateable, and most rebateable tests are conducted by private healthcare providers, highlighting their important role in the diagnosis and management of chlamydia infections in Australia.

5.3.3.3 Comparison to strategic targets for reduction of prevalence

Mathematical modelling shows that the overall testing coverage (rather than whether tests are conducted in males or females) is the key to reducing chlamydia prevalence, and that if 40% of people aged <25 years were tested annually there would be a rapid decrease in prevalence in all age groups over a 10-year period, with >50% occurring in the first 4 years (3). Our testing rate in 15-24 year olds (14%) was well below the required testing rate. Our proportion tested (20%) was more encouraging when assuming the estimated sexually active population.

Targeted testing of 20-24 year olds has a greater (~2-fold) impact on prevalence than testing 15-19 year olds or 25-29 year olds (3). Pleasingly, our testing rates were highest in the age group 20-24 years, in both males and females. Our

testing rates of 23% in females aged <25 years and 21% in females aged <30 years were particularly promising when compared to the projected rates required to reduce prevalence within 10 years (estimated at 30% in females aged <25 years and 20-30% in females aged <30 years) (3). In the estimated sexually active population, our testing rates of 35% in females aged <25 years and 30% in females aged <30 years both exceeded the projected targets. A sustained testing effort in females in this age range should impact positively on prevalence rates.

5.3.3.4 Strengths and limitations

To the best of our knowledge, this is the first study in Australia to conduct an assessment of adherence to clinical guidelines for chlamydia testing at a state-population level, and our report provides valuable evidence to guide clinical practice. The linkage of the results of all chlamydia tests enabled us to include every individual tested for chlamydia in the state over the two-year study time period, regardless of where the individual was tested. This major strength of our study enabled us to report accurate population-level rates of testing and positivity.

Our study also meets key priorities of national strategies for chlamydia control. It provides the denominator data essential to measure testing at a population level, enables a comparison to be made with the level of testing required to reduce chlamydia prevalence and evidence to evaluate prevention programs. Our methods could be applied in other geographical areas, to enable the monitoring of testing trends, and to inform targeted testing of priority populations.

Our study had several limitations. Our data reflects the population who were offered a test or who decided to get tested, and not necessarily the distribution of disease in the population. The IRSD decile scores used for the analysis of socioeconomic indicators were based on the 2011 SEIFA and we were unable to adjust for any changes that occurred in the population between 2011 and our study period (2012 and 2013). Analysis of socioeconomic indicators was limited to tests conducted in private laboratories, and it is likely that people who experience socioeconomic disadvantage are more dependent on public health care (11). The majority of tests in our study (74%) were conducted in private laboratories, minimising this limitation.

Our study was based on the population in Tasmania, and it is therefore not known whether the findings can be extrapolated to other jurisdictions. However as linkage of all chlamydia tests conducted in a population has not been reported previously and our sample size is larger than that reported by some sentinel surveillance activities (9, 14), our findings are informative. Tasmania's chlamydia notification rates in 2012 (348 per 100,000 population) and 2013 (300 per 100,000 population) were similar to those reported in other states (with the exception of the Northern Territory), particularly the eastern states (range: 292 to 361 per 100,000 in 2012, and 281 to 341 per 100,000 in 2013) (7), suggesting chlamydia infection and testing patterns might be similar across most jurisdictions.

5.3.4 Recommendations

An increase in annual testing of 15-24 year olds is needed, with a particular focus on people from disadvantaged areas and males, and on sustained testing of more than 30% of females aged 20-24 years.

Improving chlamydia knowledge may increase testing rates (24). Testing increases when clinician knowledge of testing guidelines improves (24), and acceptability of testing by young people is associated with increased knowledge about the asymptomatic nature of chlamydia, the potential sequelae and the simplicity of the testing process (25). Normalisation of testing is imperative to address stigma (24, 25); and addressing concerns about privacy, embarrassment and confidentiality may increase the likelihood of young people seeking or agreeing to a chlamydia test (21).

A considerable increase in testing could also be achieved by a change in how specimens are collected at some general practitioner (GP) clinics. Lau et al (2016) found that in 20% of young people for whom GPs requested a test, a specimen was not submitted; and the odds of not undertaking a test was 40% higher in clinics without on-site specimen collection (21). GPs are the main providers of sexual health services in Australia (1), therefore if this non-compliance in young people was able to be overcome, there would be a significant improvement in testing rates in this priority population. A sample from the first 10-20 millilitres of urine passed, taken at least 20 minutes post last void, is adequate for PCR testing; therefore, in most instances, specimen collection at time of consultation is achievable (26).

The burden of increased testing on general practitioners could be lessened by practice nurses playing a greater role (22), and by exploring alternative options to deliver testing in settings such as community pharmacies (23), which could also assist with lack of access to services.

5.3.5 Summary

We linked all chlamydia laboratory tests conducted over a two-year period and found that Tasmanian chlamydia testing coverage rates are below those recommended by clinical guidelines, particularly in males and people living in disadvantaged areas. Based on mathematical modelling estimates, overall testing rates remain too low to impact on prevalence in the short-term, however sustained testing rates in females aged 20-24 years may reduce prevalence over the next decade.

Our study provides valuable evidence to guide clinical practice and to inform national strategies. Our study method could be applied in other geographical areas, to enable the monitoring of testing trends, and to inform targeted testing of priority populations in areas of greatest need.

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Chapter 6

Geographical differences in *Chlamydia trachomatis* testing in 15-29 year-olds in Tasmania: findings from a statewide laboratory data linkage study.

Stephens N, Coleman D, Shaw K, Venn A. Geographical differences in *Chlamydia trachomatis* testing in 15-29 year-olds in Tasmania: findings from a statewide laboratory data linkage study. This paper has been accepted for publication in the *Australian Journal of Rural Health* and is currently awaiting allocation to an issue.

Chapter 6 — Geographical differences in *Chlamydia trachomatis* testing in 15-29 year-olds in Tasmania: findings from a statewide laboratory data linkage study

6.1 Preface

Lower chlamydia testing rates have been reported in areas in Australia with less access to services. Under Australian Bureau of Statistics' classification structures, Tasmania has no major cities and its mainland population resides mostly in inner and outer regional areas with a small proportion residing in remote areas. Due to its small geographical size compared to other Australian states, it has been suggested that chlamydia testing rates in Tasmania are less influenced by geographic location.

In this chapter, we describe geographical differences in chlamydia testing in young people in regional and remote Tasmania and provide a resource to guide clinical practice in the state.

This paper has been accepted for publication in the *Australian Journal of Rural Health* and is currently awaiting allocation to an issue.

6.1.1 Summary

What we already know?

- Chlamydia is Australia's most frequently notified communicable disease, and people aged 15 to 29 years account for 80% of cases.
- Chlamydia is associated with short- and long-term sequelae including infertility and increased risk of other sexually transmissible infections.

- Reducing transmission of chlamydia is a priority under Australia's National Sexually Transmissible Infections Strategy 2014-2018 and is critically dependent on adequate levels of testing and treatment of positive cases.
- Under the national strategy, 15-29 year olds are a priority population for chlamydia testing.
- The national strategy reinforces the need to address inequality in health and community care, including that related to geography.

What does this paper add?

- Provides state population level chlamydia testing rates in the at-risk age group of 15 to 29 years, by geographic location.
- Provides a method of monitoring chlamydia testing at a population level.
- Provides feedback to healthcare practitioners, particularly general practitioners who are the main providers of sexual health services in Australia.
- Provides a method of measuring testing rates by geographic location, to allow health inequalities to be addressed.

6.2 Introduction

Clinical guidelines for testing for *Chlamydia trachomatis* (chlamydia) infection recommend annual screening of all sexually active people aged 15 to 29 years(1). Lower chlamydia testing rates have been reported in areas in Australia with less access to services(2). The Australian Bureau of Statistics' (ABS) Remoteness Structure of the Australian Standard Geographical Standard divides Australia into regions that share common characteristics of remoteness (3). Under the ABS structure, Tasmania has no major cities and its mainland population is classified as residing mostly in inner (65%) and outer (33%) regional areas with a small proportion (1.5%) residing in remote areas (3). Due to its small geographical size compared to other Australian states, it has been suggested that chlamydia testing rates in Tasmania are less influenced by geographic location (4), however this has not been previously explored at a state-wide level.

The aim of this study was to describe geographical differences in chlamydia testing in young people in regional and remote Tasmania to inform clinical practice.

6.2.1 Participants, methods and results

Records of chlamydia tests conducted in 2012 and 2013 in residents of Tasmania aged 15 to 29 years were collected from all laboratories and made available to the Tasmanian Data Linkage Unit (TDLU). Test records were assigned a remoteness classification based on the ABS structure and postcode of residence at time of test. Population denominators were also obtained from the ABS. Data linkage was conducted at the TDLU. Ethical approval was received from the Tasmanian Health and Medical Human Research Ethics Committee.

We conducted analyses on all tests, and by laboratory type. We measured the number and rate of tests by remoteness classification, using Stata version 14.1 (Stata Corporation, College Station, TX, US). Laboratory type was used as a proxy for type of diagnosing healthcare provider.

There were 32,791 tests conducted in 24,753 individuals; 74% (n=24,266) in private and 26% (n=8,525) in public laboratories. The population testing rate was 13% (24,753/188,772). Testing rates were higher in inner regional areas (15%; 18,973/122,888) compared to outer regional (9%; 5555/62930) and remote areas (8%; 225/2954) (p<0.001); and higher in females (21%; n=19,340) than males (6%; n=5,413) (p<0.001). A higher proportion of tests in individuals were conducted in private laboratories (76%, n=18,698) than in public laboratories (24%, n=6,055) (p<0.001), and this difference was greater in outer regional and remote areas (Table 6.1)

Table 6.1: Rates of chlamydia testing in males and females aged 15 to 29 years in Tasmania in 2012 and 2013, by remoteness classification† and type of laboratory

		All tests		Tests in private laboratories		Tests in public laboratories		Private compared to public laboratories	
	Population	Individuals‡ tested	Testing rate	Individuals‡ tested	Testing rate	Individuals‡ tested	Testing rate	OR (95% CI)	p-value
Remoteness classification		n (%)		n (%)		n (%)			
Males									
Inner regional	63,520 (65%)	4,177	**6.6%**	2,950	4.6%	1,227	1.9%	2.5 (2.3-2.6)	<0.001
Outer regional	32,220 (33%)	1,199	**3.7%**	1,123	3.5%	76	0.2%	15.3 (12.1-19.5)	<0.001
Remote	1,550 (2%)	37	**2.4%**	37	0.3%	0	0.0%	-	-
Total	97,290 (100%)	5,413	**5.6%**	4,110	4.2%	1,303	1.3%	3.2 (3.0-3.5)	<0.001
Females									
Inner regional	59,368 (65%)	14,796	**24.9%**	10,570	17.8%	4,226	7.1%	2.8 (2.7-2.9)	<0.001
Outer regional	30,710 (34%)	4,356	**14.2%**	3,832	12.5%	524	1.7%	8.2 (7.5-9.0)	<0.001
Remote	1,404 (2%)	188	**13.4%**	186	13.2%	2	0.1%	107.0 (29.1-891.5)	<0.001
Total	91,482 (100%)	19,340	**21.2%**	14,588	16.0%	4,752	5.2%	3.5 (3.3-3.6)	<0.001

†Based on the Remoteness Structure of the Australian Standard Geographical Standard(3); ‡ individuals counted once in a 12 month period, repeat tests removed.

6.2.2 Comment

Chlamydia testing rates in the at-risk age group of 15 to 29 years are lower than those recommended under clinical guidelines, and people living in outer regional and remote areas of Tasmania are significantly less likely to be tested than those living in inner regional areas.

Australian Institute of Health data shows that most testing initiated by general practitioners is conducted in private laboratories (5). The higher use of private laboratories for chlamydia tests conducted in people living in outer regional and remote areas in our study, supports earlier findings that people living in non-urban areas in Tasmania are predominantly diagnosed by general practitioners and significantly less likely to attend sexual health or family planning clinics for diagnosis than their urban counterparts (6).

General practitioners (GPs) play a critical role in the diagnosis of chlamydia infections (6). GPs in outer regional and rural areas in Tasmania should strive to increase their chlamydia testing in the at-risk age group of 15 to 29 years, particularly in males, and need to be aware of the possibility that young people may be reluctant to attend for sexual health testing. Alternatives such as visiting services, point of care testing and teleconsultation services may improve testing rates for young people who live in areas with less access to services.

6.2.3 Limitations

Some people tested at public laboratories may have been allocated the postcode of sexual health services, corrective services and youth centres rather than their postcode

of residence. This limitation may have increased the proportion reported to be tested in inner regional areas.

6.2.4 References

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Chapter 7

Chlamydia retest and retest positivity rates: results from a state-wide laboratory data linkage study in Tasmania, 2012-2013

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Chapter 7 — Chlamydia retest and retest positivity rates: results from a state-wide laboratory data linkage study in Tasmania, 2012-2013

7.1 Preface

Young people aged 15 to 29 years account for the majority of notified cases of chlamydia and they are also more likely to be reinfected than older age groups. Reinfection with chlamydia increases the likelihood of developing pelvic inflammatory disease, ectopic pregnancy and infertility.

Clinical guidelines recommend repeat resting to check for reinfection between 3-12 months post initial treatment.

In this chapter, we report on a data linkage analysis of the results of all chlamydia tests conducted in people aged 15 to 29 years resident in Tasmania, to assess the level of retesting and retest positivity in young people who previously tested positive for chlamydia infection.

This paper has been submitted for publication to *Sexual Health* and is currently under review.

7.2 Abstract

7.2.1 Background

Chlamydia reinfection increases the likelihood of developing adverse long-term sequelae. Clinical guidelines recommend retesting at 3-12 months for individuals with positive results, to detect reinfections. We measured retesting and test positivity levels in young people who previously tested positive for chlamydia infection.

7.2.2 Methods

We linked all chlamydia tests conducted during 2012-2013 in Tasmanian residents aged 15-29 years. Retest and retest positivity rates were calculated by sex, age, socioeconomic indicators and test timeframe.

7.2.3 Results

Retest rates were higher in females than males at three months (14%, n=242/1673 v 10%, n=71/721) (p<0.01) and 12 months (27%, 265/968 v 24%, 98/410) (p=0.24). The retest rate was higher in females living in areas of most disadvantage (35%, 154/434) compared with areas of middle and least disadvantage (26% 139/534) (p<0.01). No significant differences in retest rates were found in males, by area.

Males were more likely than females to retest positive at three months (35%, 25/71 v 23%, 55/242) (p<0.01); retest positivity at 12 months was 32% in both sexes (males 98/140; females 265/968). Retest positivity was higher in males living in areas of least disadvantage (43%, 3/7) compared with middle (24%, 16/67) (p=0.27) and most (27%, 10/37) (p=0.09); and retest positivity was

higher in females living in areas of least disadvantage (39%, 7/18) compared with middle (24%, 29/121) (p<0.01) and most (31%, 48/154) (p=0.02).

7.2.4 Conclusions

Retesting rates in people previously diagnosed with chlamydia are low in Tasmania and retest positivity is high, reinforcing the importance of promoting safer sex practices to prevent reinfection, partner notification and treatment, and retesting to minimise the risk of long-term sequelae.

7.3 Introduction

Chlamydia trachomatis (chlamydia) is Australia's most frequently notified communicable disease (1) and untreated infection is associated with significant short- and long-term morbidity including adverse reproductive outcomes and increased transmission of other sexually transmissible infections (2). Individuals who test positive for chlamydia are at an increased risk of subsequently testing positive (3-5) and reinfection in females increases the likelihood of developing pelvic inflammatory disease, ectopic pregnancy and infertility (4-8).

Young people aged 15 to 29 years account for the majority of notified cases of chlamydia (9), and they are also more likely to be reinfected than older age groups (3, 10). A cohort study conducted in primary care clinics across three jurisdictions in southeast Australia found that 22% of women aged 16 to 25 years had a repeat infection within 12 months (11). In data reported by sentinel surveillance in Australia in people aged 16 to 29 years, retest positivity rates were variable. Between 1.5 and 4 months post initial positive test, retest positivity was reported as 38% in males and 13% in females reattending general practice (12) and 25% in males and 12% in females reattending family planning clinics (13). Between 1.5 and 12 months post initial positive test, retest positivity was 42% in males and 10% in females reattending general practice (12) and 33% in males and 13% in females reattending family planning clinics (13). In people aged less than 30 years reattending sexual health services, retest positivity between 1 and 4 months post initial positive test was 44% in men who

have sex with men, 21% in heterosexual males and 16% in heterosexual females (14).

The Royal Australian College of General Practitioners (15) recommends annual screening of all sexually active young people aged 15-29 years, and, if chlamydia infection is found, repeat testing to check for reinfection between 3-12 months. The Australian STI Management Guidelines (16) recommend retesting at three months for those with positive results to detect reinfections, and advises against a routine test for cure (with the exception of pregnant women and cases of rectal chlamydia). Sentinel surveillance in Australia has reported retesting rates within four months of initial positive test as between 9%-14% in males and 13%-29% in females (12,13,14); and within 1.5-12 months, as 22%-25% in males and 36%-46% in females (12,13). Retesting before four weeks post treatment is not recommended because of the risk of a false positive result due to the presence of chlamydia DNA remnants (16, 17). Furthermore, most post-treatment infections do not result from treatment failure but from reinfection from either an untreated partner or sexual activity with a new infected partner (7, 8, 18). The median length of time to reinfection has been reported as 4.6 months, with 50% of reinfections acquired between 3.5 to 6.6 months after initial infection (11).

We undertook data linkage of all chlamydia tests conducted by public and private laboratories in people aged 15-29 years in the island state of Tasmania over a two-year period. Our study design enabled us to include every test conducted in the population and to link individuals who may have been tested more than once, by more than one healthcare provider and in more than one laboratory. The aims of our study were to measure the level of retesting and

retest positivity in young people who previously tested positive for chlamydia infection, and to provide evidence to inform the clinical treatment of young people diagnosed with chlamydia. To the best of our knowledge, this is the first time in Australia that these types of analyses have been reported at a whole of state population level.

7.3.1 Methods

7.3.1.1 Study population and laboratory testing data

Records of all chlamydia tests conducted from 1 January 2012 to 31 December 2013 in residents of Tasmania aged 15 to 29 years were collected from all public and private laboratories and made available to the Tasmanian Data Linkage Unit (TDLU)(16).

7.3.1.2 Data linkage

Data linkage was conducted at the TDLU through a process of 'Probabilistic Linkage' which involved linking the data sets using a combination of unique identifiers together with a base level of administrative variables including name, address, date of birth and sex with the requirement that records being compared agree on all characters. Unique patient identifiers were created and a de-identified dataset made available to researchers for the purpose of analysis that included the following variables: laboratory identifier, unique patient identifier, postcode of residence, date of birth, sex, and result of test.

Socioeconomic indicators

Individuals were assigned an Index of Relative Socioeconomic Disadvantage (IRSD) decile score as prescribed under the 2011 Socio-economic Indexes for

Areas (SEIFA), based on their postcode of residence. SEIFA is a product developed by the Australian Bureau of Statistics that ranks areas in Australia according to their relative socio-economic advantage and disadvantage. The population-based IRSD deciles represent groups of individuals who live in similarly ranked areas. IRSD scores range from 1 to 10, with 1 being the most disadvantaged relative to the other deciles (19). For analysis purposes, IRSD scores were categorised into three groups based on deciles 1 and 2 (most-disadvantaged areas), 3 to 8 (middle-disadvantaged areas) to 9 and 10 (least-disadvantaged areas). Socioeconomic indicator analysis was restricted to people tested at private laboratories. Postcodes of people tested at public laboratories were unreliable due to an unknown proportion allocated the postcode of sexual health services, corrective services and youth centres

7.3.1.3 Analysis

We classified the first positive chlamydia test in an individual conducted within the study time period as their "initial" positive test. Retest rates and retest positivity rates were calculated for individuals with an initial positive test between 1 January 2012 and 31 August 2013, based on their first retest. Rates were calculated at 4-weekly timeframes from 4 to 16 weeks post initial positive test. A 3-month retest rate was classified as any retest occurring between ≥8 weeks and ≤16 weeks post initial positive test. Tests conducted within four weeks of an initial positive test (females n=91; males n=21) were not considered due to the possibility of false positive results (16,17).

To allow a full 12-month period post initial positive test, 12-month retest rates and retest positivity rates by agegroup, sex and disadvantage score were

calculated for those individuals with their initial positive test notified between 1 January 2012 and 31 December 2012. A 12-month retest rate was classified as a retest occurring between ≥4 weeks and ≤52 weeks post initial positive test.

The total numbers of retests conducted in males and females were also measured, again by 4-weekly timeframes from 4 to 16 weeks for all people, and between 16 and 52 weeks for those with an initial positive test in 2012.

Population denominators were derived from the estimated resident population of each collection district obtained from the Australian Bureau of Statistics for 2012 and 2013 Positivity rates were calculated by dividing the number of positive tests by the number of tests conducted. Data were analysed using Stata version 14.1 (Stata Corporation, College Station, TX, US). Differences in proportions were considered significant at $p<0.05$.

7.3.1.4 Ethical approval

This study was approved by the Tasmanian Health and Medical Human Research Ethics Committee.

7.3.2 Results

7.3.2.1 Retesting rates

A total of 31,899 nucleic acid tests were conducted in 24,830 individuals between 1 January 2012 and 31 August 2013. Of those, a total of 1,673 females and 721 males tested positive between 1 January 2012 and 31 August 2013. The retest rate at the recommended 3-month timeframe was significantly higher in females (14%, n=242) than in males (10%, n=71) ($p<0.01$). The retest rate

between 1-4 months was also higher in females (21%, n=349) than males (18%, n=128) (p=0.09) (Table 7.1).

Amongst the 2012 cohort, the retest rate during the period 1-12 months post initial positive test was slightly higher in females (27%, n=265/968) than in males (24%, n=98/410) (p=0.24). By timeframe of test, the highest retest rates in females were found in weeks 16-52 (16%) and weeks 8-12 (9%), and in males in weeks 16-52 (12%) and weeks 4-8 (8%) (Table 7.1).

7.3.2.2 Demographic differences in retesting rates

Higher levels of retesting were observed in males living in areas of middle disadvantage, compared with retesting of males living in areas of most or least disadvantage, however the differences were not statistically significant between any of the groups. There was significantly more retesting in females living in areas of most disadvantage compared with females living in areas of middle and least disadvantage ($p<0.01$) (Figure 7.1).

Table 7.1: Retest rates and retest positivity rates* in individuals aged 15 to 29 years resident in Tasmania with an initial positive chlamydia test between 1 January 2012 to 31 August 2013

	Individuals with an initial positive test, N	4-<8 weeks		8-<12 weeks		12-≤16 weeks		**3-month retest^**		16-≤52 weeks~		**12-month retest~**	
		Individuals, n (%)		Individuals, n (%)		Individuals, n (%)		**Individuals, n (%)**		Individuals, n (%)		Individuals, n (%)	
Males		Retested	Positive	Retested	Positive	Retested	Positive	**Retested**	**Positive**	Retested	Positive	Retested	Positive
15-19 yrs	229	21 (9%)	2 (10%)	13 (6%)	6 (46%)	13 (6%)	2 (15%)	**26 (11%)**	**8 (31%)**	11/136 (8%)	2 (18%)	**35/136 (26%)**	**9 (26%)**
20-24 yrs	353	25 (7%)	5 (20%)	19 (5%)	9 (47%)	15 (4%)	8 (53%)	**34 (10%)**	**17 (50%)**	19/190 (19%)	4 (21%)	**36/190 (19%)**	**14 (39%)**
25-29 yrs	139	11 (8%)	1 (9%)	7 (5%)	0 (0%)	4 (3%)	0 (0%)	**11 (8%)**	**0 (0%)**	16/84 (19%)	6 (38%)	**27/84 (32%)**	**8 (30%)**
Females													
15-19 yrs	785	55 (7%)	7 (13%)	68 (9%)	13 (19%)	45 (6%)	15 (33%)	**113 (14%)**	**28 (25%)**	80/474 (17%)	28 (35%)	**139/474 (29%)**	**47 (34%)**
20-24 yrs	681	37 (5%)	6 (16%)	52 (8%)	8 (15%)	42 (6%)	12 (29%)	**94 (14%)**	**20 (21%)**	64/379 (17%	16 (25%)	**94/379 (25%)**	**29 (31%)**
25-29 yrs	207	15 (7%)	3 (20%)	24 (12%)	6 (25%)	11 (5%)	1 (9%)	**35 (17%)**	**7 (20%)**	14/115 (12%)	3 (21%)	**32/115 (28%)**	**8 (25%)**
All males	721	57 (8%)	8 (14%)	39 (5%)	15 (38%)	32 (4%)	10 (31%)	**71 (10%)**	**25 (35%)**	46/410 (11%)	12 (26%)	**98/140 (24%)**	**31 (32%)**
All females	1673	107 (6%)	16 (15%)	144 (9%)	27 (19%)	98 (6%)	28 (29%)	**242 (14%)**	**55 (23%)**	158/968 (16%)	47 (30%)	**265/968 (27%)**	**84 (32%)**

*Retested between ≥4 and ≤52 weeks post initial positive test; ^≥8 and ≤16 weeks post initial positive test; ~calculated on 2012 cases only

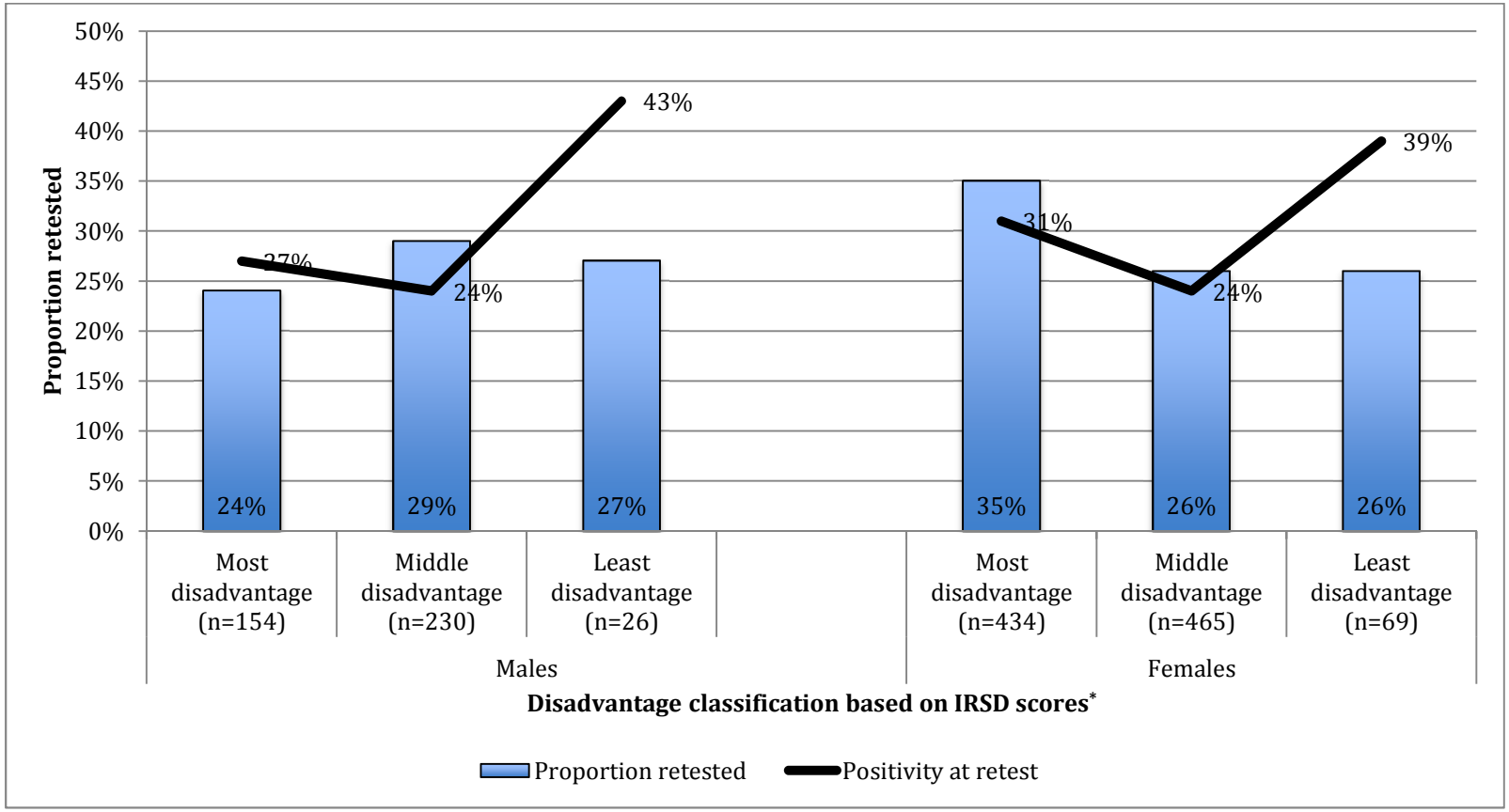

Figure 7.1: Proportion of males and females aged 15 to 29 years tested in private laboratories with an initial positive chlamydia test between 1 January 2012 and 31 December 2012, who were subsequently retested for chlamydia, by IRSD score*

*Australian Bureau of Statistics' IRSD scores(19) range from 1 to 10, with 1 being the most disadvantaged relative to the other deciles. For analysis purposes, IRSD decile scores were divided into three groups, ranging from 1 and 2 (most disadvantaged areas, population 195,867), 3 to 8 (middle disadvantaged areas, population 255,377) to 9 and 10 (least disadvantaged areas, population 42,947).

7.3.2.3 Positivity rates at retest

The majority of reinfections were found between weeks 12 and 16 in both males (55%) and females (52%) (Table 7.1).

Males were more likely than females to test positive in retests conducted between 4 and 16 weeks post initial positive test (p=0.03) (with the exception of retests conducted at 4-8 weeks), and at the 3-month timeframe (males 35%, females 23%) (p<0.01). By agegroup and sex, the highest rates of reinfections at 3 months were found in males aged 20-24 years (50%) followed by males 15-19 years (31%) and females 15-19 years (25%) (Table 7.1).

There was no overall difference between male and female retest positivity in those who were retested between 4-52 weeks after their initial positive test (both 32% positivity). By age group and sex, males aged 20-24 years continued to have the highest rates of reinfection (39%), followed by females 15-19 years (34%) and females 20-24 years (31%) (Table 7.1).

7.3.2.4 Demographic differences in retest positivity

Males living in least disadvantaged areas were more likely to retest positive than males living in middle disadvantaged areas (p=0.04) and most disadvantaged areas (p=0.09). Females living in least disadvantaged areas were more likely to retest positive than females living in most (p=0.02) and middle (p<0.01) disadvantaged areas (Figure 7.1).

7.3.2.5 All retests

A total of 1,208 retests in 598 females, and 287 retests in 195 males, were conducted over the study period. Females were more likely than males to have multiple retests up to 16 weeks (p<0.01). There was no significant difference between the sexes in having multiple retests conducted between 4 and 52 weeks (Figure 7.2).

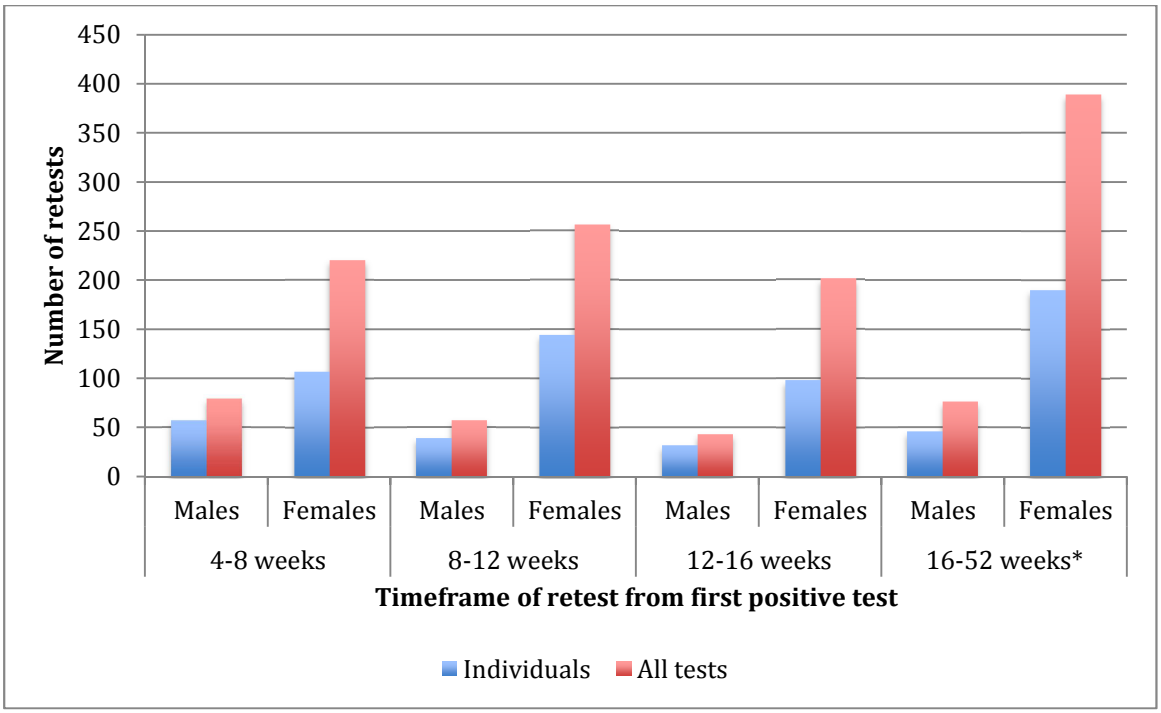

Figure 7.2: Number of retests in individuals and overall number of retests between 4 and 52 weeks post initial positive chlamydia test, in residents of Tasmania aged 15 to 29 years with an initial positive test for chlamydia between 1 January 2012 and 31 August 2013

*calculated on cases with initial positive test between 1 January 2012 and 31 December 2012

7.3.3 Discussion

7.3.3.1 Retesting rates and reinfections

In this whole of state population-based data linkage study, we measured chlamydia retest rates and retest positivity rates in individuals aged 15 to 29 years resident in Tasmania who had previously tested positive for chlamydia. Rates of retesting at the recommended 3-month timeframe (15, 16) were low in both males (10%) and females (14%); and, despite an increase when measuring retests up to 12 months post initial positive test, the retest rates remained low (males 24%; females 27%). Retest positivity was high in both males and females at the 3-month retest timeframe (35% and 23% positivity, respectively), and at the 12-month retest timeframe (both 32% positivity). These reinfection rates are significantly higher than the annual chlamydia positivity rates observed in the same population over the same time period (males 6%; females 21%) (both $p<0.001$) (20). The majority of reinfections were detected between 12 and 16 weeks post initial positive test, highlighting this timeframe as the most appropriate period for retesting.

The low retest rates and high retest positivity rates are of considerable concern due to the increased risk of long-term sequelae in people with chlamydia reinfections.

7.3.3.2 Demographic differences in retesting rates and reinfections

The higher levels of retesting in females living in areas of most disadvantage might be explained by the cost of attending a medical appointment. Data collected as part of a census of Tasmanian general practices in 2014 (21) shows that general practitioners (GPs) practicing in areas of most disadvantage are

significantly more likely to offer bulk billing[a] to their patients than GPs practicing in areas of least disadvantage (50%, n=45/90 practices; compared with 31%, n=17/55 practices) (p=0.02) (unpublished data, Primary Health Tasmania); and a community-based Australian survey conducted in 2013 found that people with lower income levels were significantly more likely to be offered bulk billing (23). Therefore, females living in areas of least disadvantage are less likely to be offered bulk billing, and the cost of an appointment for the purpose of a retest may be prohibitive for this cohort.

In both males and females, retest positivity was higher in individuals living in areas of least disadvantage. Reasons for this discrepancy could include higher levels of health literacy and health-seeking behaviour (24) in people living in areas of least disadvantage, which may result in those at higher risk of reinfection self-presenting for retesting. Also, people living in most disadvantaged areas are less likely to have long GP consultations than people living in more advantaged areas (25). A shorter consultation could impact on the ability of GPs to ensure their patients are aware of the need for retesting when at high risk of reinfection, and may also result in GPs having less knowledge of the patients' risk histories.

7.3.3.3 Comparison with other Australian studies

Our retest rates in males were very similar to the retest rates reported by sentinel surveillance in Australia, both at 3-month retest (our rate 10%, sentinel surveillance rate 9%-14% (12-14)) and at 12-month retest (our rate 24%,

[a] Bulk billing is when health professionals accept the Medicare benefit as full payment for a service (22).

sentinel surveillance rate 22%-25% (12, 13)). Our male retest positivity at 3-month retest was mid-range of that reported by sentinel surveillance (35% compared with 21%-44%(12-14)) and slightly lower at 12-month retest (32% compared with 33%-42% (12, 13)).

Our retest rates in females of 14% at 3-month retest and 23% at 12-month retest were lower than the female retest rates reported by sentinel surveillance (13%-29% (12-14) and 36%-46% (12, 13), respectively). Our female positivity at retest, however, was considerably higher at both the 3-month retest (23%) and 12-month retest (32%) compared with the rates reported by sentinel surveillance (12%-16% (12-14) and 10%-13% (12, 13)), and higher than the rate of 22% reported by an Australian cohort study (11).

There are several differences between our study and the cohort study and sentinel surveillance that might explain these varied findings. The main difference is that our study was based on a whole state population, whereas the cohort study and sentinel surveillance were based on population samples and may have been biased by selection factors. The study and sentinel surveillance rates are based on the person reattending the same clinic, whereas, in our study, we captured every test in every individual regardless of where they attended and linked them to enable us to report a population rate. It is possible that retest and retest positivity rates were underestimated in the study and sentinel surveillance data, through failure to capture patients retesting at more than one clinic site. It is also possible that retest rates and retest positivity are different in Tasmania than in the areas reported by the cohort study and sentinel surveillance.

7.3.3.4 Potential reasons for low retesting rates

There are several potential explanations for the low retesting rates, including clinical discretion. Clinicians may be selecting those at highest risk of reinfection (targeted retesting) and retesting them often. Our results show high retest numbers in individuals retested for chlamydia and support this assertion.

Patients themselves may be self-selecting, based on their self-assessed risk. As chlamydia is asymptomatic in up to 80% of cases, there is a risk that asymptomatic people may not see themselves as high risk and they may be less likely to present for a retest (18) and some patients may not perceive retesting as a priority, leading to variation in patient adherence to recommendations to retest (14). However, findings of a study in the United Kingdom are encouraging. They showed that a quarter of patients that did not consent to a reminder to retest accurately assessed their own risk and sought chlamydia retesting actively, and were more likely to be infected than those who had consented to be contacted (4).

The high retest positivity rates found in our study support the hypotheses of targeted testing by clinicians and self-selection for retesting by high-risk patients.

7.3.3.5 Ways to increase retesting rates

Retesting rates improve significantly when SMS reminders are sent to patients (4, 14) and, for some patients, retesting rates increase even more when combined with the provision of home kits for self collection of samples (14, 18, 26). Home test kits also alleviate another one of the barriers to retesting – the time and effort involved in going back to the clinic (27). Social circumstances

impact patients' retesting preferences, therefore providing choice of retesting methods is important (4, 12, 18).

Actions taken by clinics can also improve retest rates, such as robust data systems to enable auditing of retests (4, 16) and increasing clinicians' knowledge about management of chlamydia infections (28). Practice nurses could also play a more active role in chlamydia retesting (28).

7.3.3.6 Strengths and limitations

The greatest strength of our study was that it was based on the whole population of 15 to 29 year-olds living in Tasmania. The linkage of all individuals' chlamydia tests enabled us to report accurate population-level retesting and retest positivity rates. Retesting is vital to identifying and treating repeat infections (18) and our paper provides an accurate feedback mechanism to clinicians on their retesting efforts.

Our study had several limitations. Our data reflects the population who were offered a retest or who decided to get retested, and not necessarily the distribution of reinfection in the population. Our study was based on the population in Tasmania, and it is not known whether the findings can be extrapolated to other jurisdictions. However, our sample size is large and as this is the first study to report retest and retest positivity rates at a state-population level, our findings are informative. Tasmania's chlamydia notification rates in 2012 and 2013 were very similar to those reported in other eastern Australian states (29), suggesting infection and testing patterns are similar across jurisdictions.

7.3.3.7 Recommendations

It is important that clinicians treating patients with chlamydia infections ensure their patients are aware of the potential consequences of reinfection including the increased risk of long term sequelae such as infertility. Clinicians should also educate their patients on safer sex behaviours to prevent reinfection, particularly the importance of the use of condoms (30).

Clinicians should seek guidance from their patients on the most appropriate way to ensure a retest occurs at 3-months post initial diagnosis. Practice nurses could be engaged to assist with the retest workload in clinics, and reminder systems within clinics could ensure follow up of at risk patients occur.

Clinicians could focus their retesting efforts at 12 to 16 weeks post treatment, to prevent excess retesting of individuals at timeframes when reinfections are less likely to be detected. Continued clinical discretion can ensure adequate levels and frequency of retesting in those at highest risk. Where possible, clinicians should offer bulk billing at time of retest.

7.3.3.8 Summary

We linked all chlamydia tests conducted over a two-year period to individuals and found that retesting rates of patients previously diagnosed with chlamydia are low, particularly at the recommended timeframe for retesting (3 months). Chlamydia retest positivity was high in both males and females, reinforcing the importance of increasing the use of condoms amongst priority populations to prevent reinfection, partner notification and treatment, and retesting to minimise the risk of long term sequelae.

Our study provides valuable evidence to inform clinical practice, and our methods could be applied in other geographical areas to enable the monitoring of retesting trends. Our study also provides a method to monitor the proportion of chlamydia tests that yield a positive test in the 15-29 year age group, which is a priority under the National Blood-borne Viruses and Sexually Transmissible Infections Surveillance and Monitoring Plan 2014-2017 (30).

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Chapter 8

Discussion

Chapter 8 — Discussion

8.1 Introduction

This thesis includes analyses of four datasets collected in Tasmania: i/ statutory data on all *Chlamydia trachomatis* (chlamydia) cases notified to the Tasmanian Department of Health and Human Services between 2001 and 2010; ii/ demographic and clinical information collected on all notified chlamydia cases between 2001 and 2010; iii/ the results of all chlamydia laboratory tests conducted in the state between 2001 and 2010; and iv/ the results of linked chlamydia laboratory testing data in 2012 and 2013. The central aims of this research were to provide an evidence base from which prevention, intervention and control activities can be planned, monitored and evaluated; and methods that can be utilised in other geographical locations for the same purposes. The following sections provide a summary of the key findings, the limitations of the study, and public health implications and outcomes.

8.2 Summary

The key findings and contributions to the literature from this dissertation are as follows:

- This study was the first in Australia to provide a comparison of chlamydia notification rates by subgroups derived from a population-based dataset collected over a 10-year period (**Chapter 2**). The study results demonstrated that the large majority of males (84%) and females (71%) notified with chlamydia were diagnosed by general practitioners; however the range and the differences between the sexes and across age

groups in choice of healthcare provider highlighted the importance of the availability of a variety of services. We found females were more likely to have been tested for chlamydia infection as a result of screening (50%), whereas males were more likely to have been tested when presenting with symptoms (52%). Our data demonstrated significant under-reporting in males, highlighting the need for strategies to improve screening in males.

- This study was the first in Australia to measure chlamydia test positivity at a population level over a 10-year period and compare the results to notification data (**Chapter 3**). We found increases in chlamydia infections that remained after allowing for testing effort, inferring that the prevalence of chlamydia increased over the 10 years in Tasmania. Large increases in testing occurred, particularly in young males, indicating that healthcare providers are striving to reach the testing goals and that the gender gap in testing practices is narrowing. We demonstrated that the analysis of laboratory testing data is useful for surveillance purposes and can be achieved through an extraction of data routinely collected by laboratories. Monitoring trends in population-level chlamydia testing is sustainable and could be included in public health surveillance activities.
- This study was the first in Australia to examine the symptom status, reason for testing and sexual exposure of people aged 15 to 29 years notified with chlamydia over a 10-year period, and to compare the results to laboratory testing data conducted over the same time period (**Chapter 4**). A key public health goal, fundamental to the strategies to control the chlamydia epidemic in Australia, is to reach adequate levels of testing for

chlamydia in sexually active young people, both asymptomatic and symptomatic (1). Our results showed that the proportion of diagnoses in asymptomatic people increased, with the largest increases observed in young males, and that the proportion of male cases tested as a result of screening also increased. We found that after allowing for any changes in sexual exposure, symptom status and reason for testing, an increase in chlamydia test positivity occurred over the 10 years, and that healthcare providers have increased their chlamydia testing rates in high-risk groups.

- For the first time in Australia, **Chapter 5** reports the results of data linkage of all chlamydia testing conducted at a state population level over a two-year period. Our study design enabled us to include every test conducted in the population and to link individuals who may have been tested more than once, by more than one healthcare provider and in more than one laboratory, enabling us to report true population rates of testing and test positivity. We compared our results to clinical guidelines (2, 3) and to the estimated testing levels required to reduce chlamydia prevalence. Chlamydia testing rates are lower than those recommended under clinical guidelines in both males and females; however, testing in females 20 to 24 years is approaching the estimated level required to reduce chlamydia prevalence over the next 10 years (4). Our study provided a robust methodology that can meet the requirements of the Australian National Sexually Transmissible Infections Strategy (1) by monitoring testing coverage and providing evidence to evaluate prevention and control programs.

- Lower chlamydia testing rates have been reported in regional and rural areas in Australia due to less access to testing (5). Tasmania's population mostly resides in inner and outer regional areas (6), however due to its small geographical size compared to other Australian states, it has been suggested that chlamydia testing rates in Tasmania are less influenced by geographic location (7). This study (**Chapter 6**) provides evidence of testing levels at a geographical level in Tasmania and is a useful resource to guide clinical practice in the state. We found that people living in outer regional and remote areas in Tasmania are significantly less likely to be tested than those living in inner regional areas.
- Chlamydia reinfection increases the risk of long-term sequelae including adverse reproductive outcomes and increased transmission of other sexually transmissible infections (8); and individuals who test positive for chlamydia are at an increased risk of subsequently testing positive (9-11). For this reason, clinical guidelines (2, 3) recommend repeat testing of those with positive tests, to check for reinfection. For the first time in Australia, this study of a whole population (**Chapter 7**) measured the level of retesting and retest positivity in young people who previously tested positive for chlamydia. We found retest rates at the recommended timeframe were low in both males (10%) and females (14%); and that test positivity was significantly higher than the annual chlamydia positivity rates found in the same population. Our study provides important evidence to guide clinical practice and our methods could be applied in other geographical areas to enable the monitoring of retesting trends.

8.3 Limitations

There are a number of potential limitations in this research that should be considered when interpreting the findings.

Firstly, the data collected from notified cases in our study was based on individuals who were mostly tested as a result of symptomatic presentation or screening. A large proportion of chlamydia infections are asymptomatic (4), therefore a large proportion of both males and females with chlamydia infections may not get diagnosed. Any differences between individuals who were diagnosed and individuals who were not diagnosed are unknown. Additional surveillance data, beyond basic demographic details, was not collected for 15% of notified cases, however there were no differences found in the age, sex or geographic location of the cases for whom we collected data and for whom we did not, reducing the risk of selection bias.

A range of commercial nucleic acid tests with minor variations in lower limits of detection were used in laboratories throughout the period of the study. This may have had a small influence on the positivity rates. Local and temporal changes in specimen type may also have impacted the detection rates (L. Cooley, Head of Microbiology, Royal Hobart Hospital, Tasmania, personal communication, 2014).

In the unlinked laboratory data collected from 2001 to 2010, we found 7% more positive tests than notified cases over the same time period. This difference might be explained by the inclusion of repeat tests or underreporting in the

notification data. The limitation was consistent over the 10 years and should not impact the observed trends.

Our analyses of both the notification data and the unlinked laboratory data were limited by their deidentified nature. We were unable to ascertain whether a person was tested or notified more than once in each year. We addressed the limitation of deidentified data in our studies presented in Chapters 5, 6 and 7, in which we linked all testing data over a two-year period. Still, as in previous chapters, the data reflected the population who were offered a test or who decided to get tested, and not necessarily the distribution of the disease in the population.

Due to an unknown proportion of individuals tested at public laboratories being allocated the postcode of sexual health services, corrective services and youth centres, we restricted our socioeconomic indicator analysis to tests conducted in private laboratories. It is likely that people who experience socioeconomic disadvantage are more dependent on public health care (12) and this may have influenced the results. We included public laboratory data in our geographical analysis, which may have inflated the proportion tested in inner regional areas.

The descriptive analyses conducted on the data included in Chapters 5 and 7 were adequate to meet the aims of the project, ie. to measure the rates of testing and retesting at a state-wide level in order to compare adherence to clinical guidelines and to compare to the projected levels required to reduce chlamydia prevalence. Future research could be expanded to include exploration of alternative hypotheses, such as the impact of remoteness on testing levels, through multivariable regression analysis.

The research presented in this thesis is based on the population in Tasmania, and it is not known whether the findings can be extrapolated to other geographical areas. However, Tasmania's chlamydia notification rates are very similar to those reported in other eastern states of Australia (13) (Figure 8.1), suggesting chlamydia reinfection and testing patterns might be similar across jurisdictions. Our sample size was also larger than that reported by sentinel surveillance activities, and our findings are therefore informative.

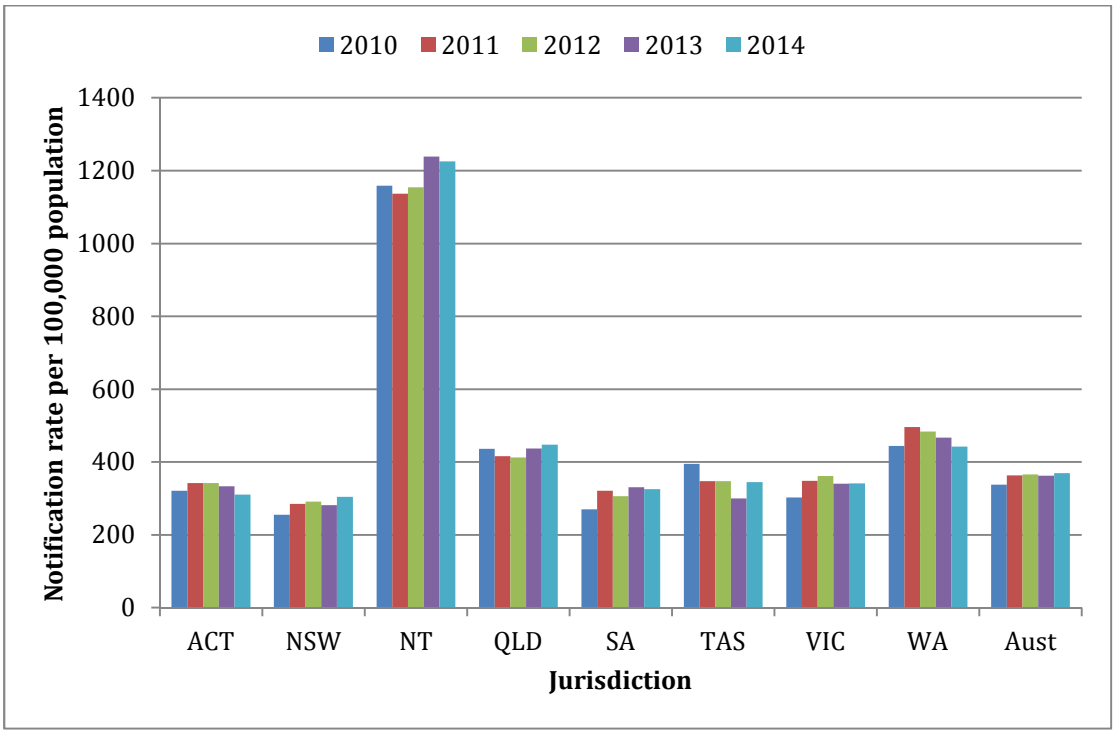

Figure 8.1: Notification rate per 100,000 population, chlamydia infection, Australia, 2010 to 2014, by jurisdiction

(Sourced from: Australian Government Department of Health, National Notifiable Diseases Surveillance System, available at: http://www9.health.gov.au/cda/source/cda-index.cfm)

8.4 Public health implications of this research

8.4.1 Chlamydia surveillance

Chlamydia notifications have been increasing since the condition first became notifiable in 1994 (Figure 8.2).

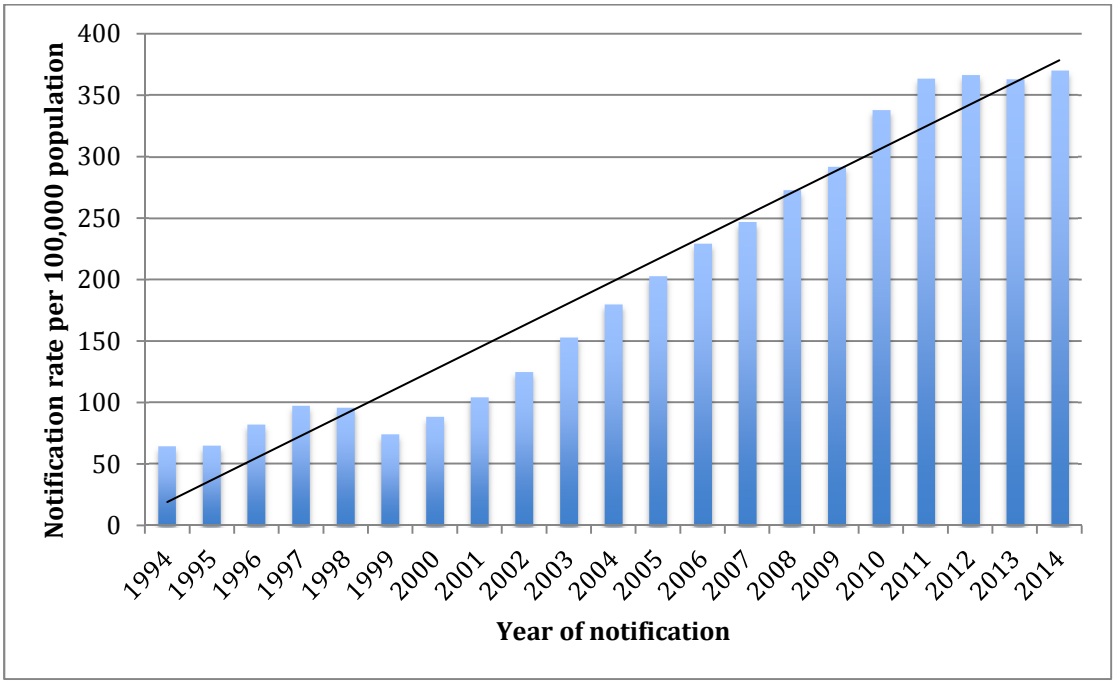

Figure 8.2: Notification rate per 100,000 population, chlamydia infection, Australia, 1994 to 2014(13)

(Sourced from: Australian Government Department of Health, National Notifiable Diseases Surveillance System, available at: http://www9.health.gov.au/cda/source/cda-index.cfm)

A range of public health actions to control chlamydia infection need to be employed simultaneously in order to be effective in reducing the burden of disease associated with infection and to reduce population prevalence. These strategies include: primary prevention (health promotion, education, access to condoms); and targeted clinical services and management of population groups at greatest risk of infection (8). Priority actions developed under the Australian National Sexually Transmissible Infections Strategy to address the chlamydia

epidemic and of particular relevance to the public health surveillance of chlamydia, include: i/ improving the surveillance of the incidence of chlamydia in priority populations, ii/ improving methods of monitoring testing coverage, and iii/ the development and promotion of nationally consistently STI testing and retesting guidelines (1). The current method of conducting passive surveillance is inadequate and cannot meet these priority action items. Current surveillance is based on notifications of diagnosed cases (14) and does not provide the vital testing information needed to understand trends in notification data; inform, monitor and evaluate prevention and control activities; and monitor testing coverage. The methods developed and presented in this thesis directly meet priorities i and ii described above, and provide evidence to guide the development of priority action iii.

This study has shown it is possible, and a lot more useful, to monitor the proportion of positive tests and testing coverage by the collection, analysis and reporting of laboratory testing data. By inclusion of sex, age and postcode with the result of test, it is possible to target interventions towards at risk groups. The methods presented in this dissertation would enable health authorities to conduct tight geographical analyses of laboratory data, and target interventions at a local level. For example, an annual chlamydia testing rate of 30% in females aged 20 to 24 years is predicted to decrease the prevalence of chlamydia dramatically, with 50% of the decrease occurring in the first four years (4). Figure 8.3 shows the annual testing rate in 2012 and 2013 in females aged 20 to 24 years by regions of Tasmania. The map shows very clearly where particular focus and promotion of testing is required to increase testing to 30%. Health

authorities could analyse testing data by an even smaller geographical area and then target their messages appropriately. For example, analysis by local government area could be mapped and provided to: doctors practicing in areas with inadequate levels of testing to encourage them to increase their testing levels; local government to design campaigns promoting the importance of being tested; and local schools, colleges and universities to develop and implement education messages.

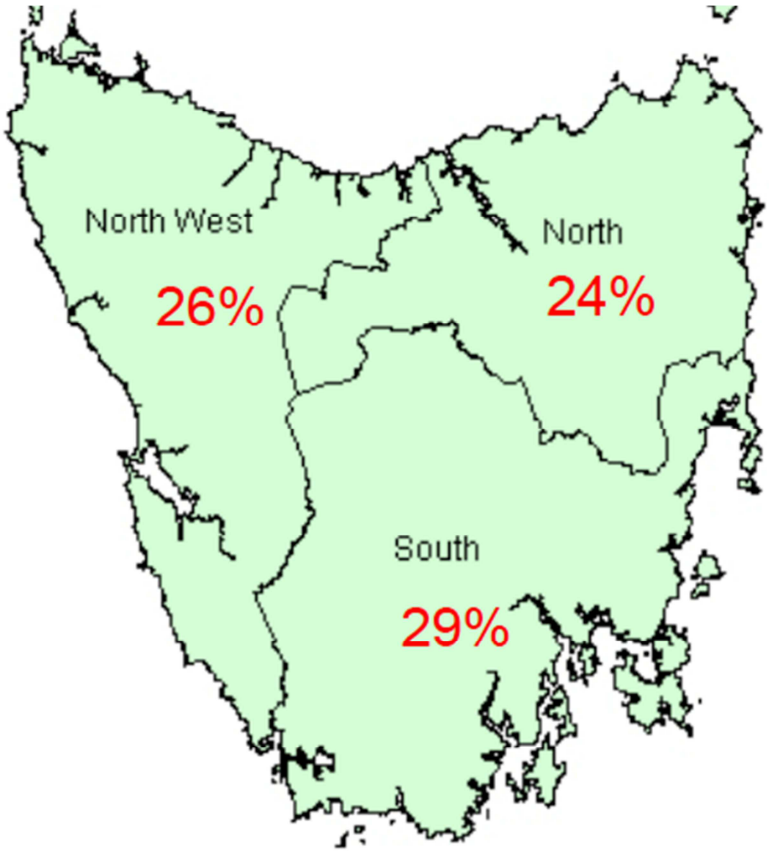

Figure 8.3: Rate of chlamydia testing in females aged 20-24 years in 2012 and 2013 in Tasmania, by region

Collection of additional data on notified cases, such as symptom status (Chapter 3) also meets a priority of the National Sexually Transmissible Infections

Strategy (1), that is, to identify and address emerging issues. As chlamydia is mostly asymptomatic (15-17), regular testing of all sexually active young people, not just those who present with symptoms, is a vital component of strategies to increase testing efforts (1). Our method of collecting additional data from the treating doctors of notified cases could be implemented in other Australian jurisdictions to monitor the level of testing in asymptomatic young people. Collection of additional surveillance data at a population level can be resource intensive in jurisdictions with large populations, however targeted periodic surveys could be implemented.

Periodical data linkage should also play an important role in chlamydia surveillance. Trends in testing rates can be monitored through analysis of deidentified laboratory datasets; however the gold standard in monitoring testing trends is linking tests conducted in individuals and reporting on population testing rates. This type of analysis is resource intensive and potentially not feasible as a routine surveillance method in some jurisdictions. Under those circumstances, periodical data linkage would provide valuable evidence to support the routinely collected testing data, and is particularly important for monitoring what proportion of the population who test positive subsequently receive a retest.

8.4.2 Application of the method to other disease surveillance

Our methods would be equally valuable for surveillance of some other diseases, such as influenza. Notification rates of influenza in Australia were relatively stable and below 50 cases per 100,000 population until 2006. Since that time there has been a sharp increase in notification rates (Figure 8.4). It has been

argued that the increase in influenza notifications is a testing artefact. The introduction of an item number in the Australian Medicare benefits schedule in 2004 (18) led to a steady increase in influenza testing. This has been most evident from 2007 and is possibly linked to heightened awareness since the publicised deaths in children associated with influenza in 2007, and from the pandemic in 2009 (19). At the same time, syndromic and hospital-based surveillance activities in Australia have indicated that there has not been a concomitant increase in influenza-like-illness burden or influenza disease severity (20). As public health surveillance of influenza is also reliant on passive notification of diagnosed cases, the true impact of testing practices on rates over time cannot currently be measured.

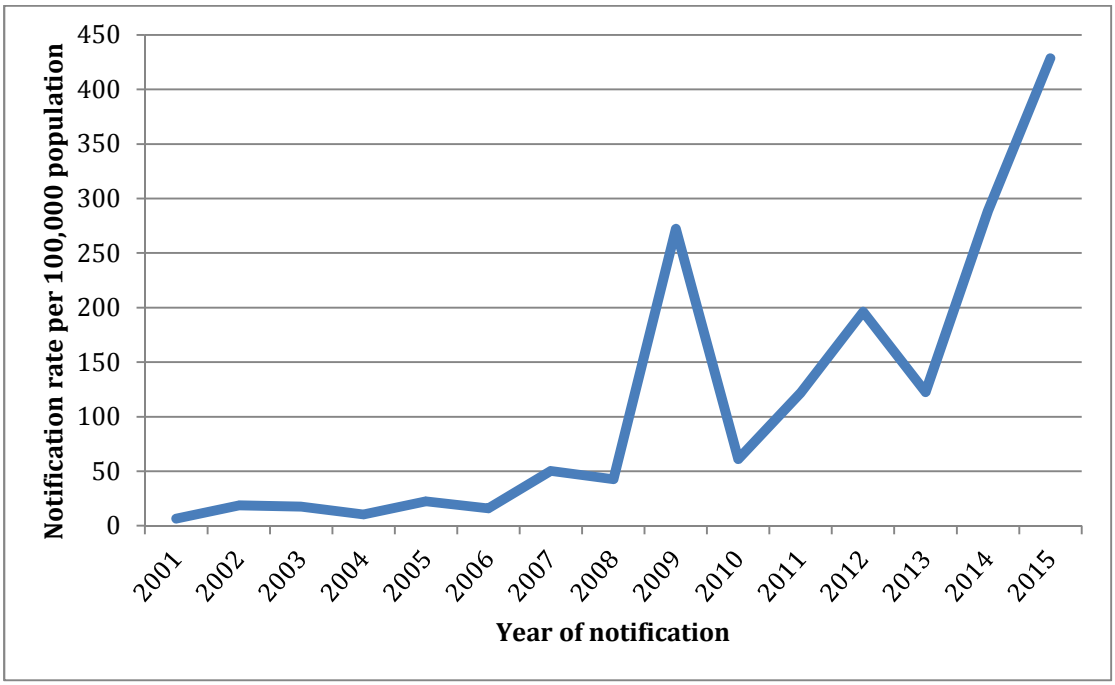

Figure 8.4: Notification rate per 100,000 population, influenza, Australia, 2001 to 2015

(Sourced from: Australian Government Department of Health, National Notifiable Diseases Surveillance System, available at: http://www9.health.gov.au/cda/source/cda-index.cfm)

Reporting under the current influenza surveillance system (passive reporting of diagnosed cases) not only limits the ability to plan, monitor and evaluate public health policies and interventions, but also creates an environment where misinterpretation occurs. The large number of influenza notifications in recent years has led to increased media interest with headlines and articles that can create concern in the community (Figure 8.5).


National

Flu epidemic hits with diagnoses running at double the average for this time of year

July 7, 2015 10:00pm

Sue Dunlevy National Health Reporter News Corp Australia Network

Figure 8.5: News Corp Australia Network. "Australia is in the grip of a flu explosion with diagnosed cases this year more than double the five year average and 2,000 people testing positive for the virus in the last week."

Available at: http://www.adelaidenow.com.au/news/national/flu-epidemic-hits-with-diagnoses-running-at-double-the-average-for-this-time-of-year/news-story/b7afb25d471d25eb8f1bffb1e6187deb

As well as enabling a measured response to community concern about rising numbers of reported diagnoses, collection of high quality laboratory testing data for influenza is needed to enable monitoring and reporting of trends, and to gauge the timing and peak of the influenza season and to improve pandemic

preparedness activities (21). The methods presented in this thesis would meet those needs.

8.4.3 Legislative change

In order to report on testing trends and test positivity, health authorities require the testing data from laboratories; that is, they require details of all negative tests, not just those of diagnosed cases. Under current legislation in Tasmania, (the Public Health and Wellbeing Act 1997 and the Guidelines for Notifying Diseases and Food Contaminants (22)), laboratories are only required to notify the department when a person has evidence of a notifiable disease. Similar legislation is in place in other states and territories in Australia.

There are two options available, either an amendment to the Guidelines (22) to require laboratories to report negative tests; or, establishment of a Memorandum of Understanding between health authorities and laboratories to create an environment where laboratories are supported and secure in providing the data to health authorities.

There are several overseas examples of health authorities successfully collecting laboratory data for chlamydia surveillance purposes. In New Zealand (where chlamydia is not a notifiable condition), the health authorities receive laboratory testing data and measure trends in testing and test positivity for surveillance purposes (23, 24); and in the United Kingdom, chlamydia testing data is collected from all National Health Service (NHS) and NHS-commissioned laboratories. Norway implemented a laboratory based surveillance system in 2005, whereby they collect the total number of chlamydia tests performed and the number of diagnosed cases once a year from all laboratories, and in 2007 improved their

system to collection additional information on age, sex and geography in order to better interpret trends (25).

8.5 Outcomes of this research

To date, public health actions have been taken in both Tasmania and Victoria as a result of the findings of this research.

Tasmania has changed its legislation to allow laboratories to notify chlamydia in a less resource intensive way than previously. Prior to 2016, laboratories were required to notify individual diagnoses of chlamydia to the Tasmanian Department of Health and Human Services (DHHS). The new Guidelines now allow a password protected spreadsheet of diagnoses found in the immediately preceding month to be forwarded to the DHHS on the 5th working day of the month (26). This initiative is progress towards an electronic method of notification, has resolved the considerable workload associated with notification of single diagnoses, and still allows the monitoring and reporting of notification trends.

The Tasmanian DHHS is currently documenting its plans to continue to collect laboratory testing data and report on trends in testing and positivity. These plans include bi-annual data linkage of laboratory testing data to enable ongoing monitoring, analysis and reporting of chlamydia testing, retesting and test positivity (personal communication, Senior Surveillance Officer, DHHS). This will enable ongoing, targeted public health prevention and control activities to be undertaken; and for advice to be provided to Tasmanian clinicians on where they need to focus their testing, based on accurate, population-level data. The

new method in Tasmania will be in line with that presented in Chapters 5, 6 and 7 of this thesis.

In Victoria, a larger southern state of Australia with a population of approximately 6 million, the Victorian Department of Health and Human Services has commenced negotiations with pathology laboratories to seek chlamydia testing results on a quarterly basis. The data to be collected will include age, sex, postcode and result of test for both diagnosed cases and for negative tests. This will enable Victoria to monitor, analyse, report and target their public health interventions, and to provide clinicians with valuable feedback to inform their testing practices (sourced from internal document - minutes of three meetings of the Victorian Department of Health and Human Services' Laboratory Liaison Committee). The data to be collected by Victoria will be in line with that presented in Chapter 3 of this thesis.

These actions will result in both Tasmania and Victoria meeting a number of the key priority actions of the National Sexually Transmissible Infections Strategy (1), and thereby have a positive impact on the efforts to control the chlamydia epidemic in those two jurisdictions.

8.6 Conclusion

The fundamental purpose of public health surveillance is to inform public health action and policy (27, 28). Current passive surveillance of chlamydia diagnoses cannot meet that purpose. This dissertation has demonstrated a new and better way of conducting surveillance that is achievable in Australia. It is possible to collect laboratory testing data to adjust for changes in testing practices and

provide valuable epidemiological reports that meet public health requirements. The data presented in this dissertation can be used to inform policy and to provide advice and guidance to healthcare practitioners; and the methods ensure key priorities of the National Sexually Transmissible Infections Strategy are met (1).

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Appendix A

Appendix A — Preface

In this Appendix, I include the paper, *Role of the general practitioner in testing for genital Chlamydia trachomatis infection: an analysis of enhanced surveillance data* (Shaw K, **Stephens N**, Coleman D, O'Sullivan M) published in *Sexual Health* 2009, 6, 208-212. This paper was based on data analysed as part of the study described in Chapter 3 of this dissertation. My contribution to this paper included all of the data analysis, contribution to the interpretation of the data and revision of the manuscript, contribution to the conceptualisation of the study, and contribution to the acquisition of the data.